TETRA TECH

OQM | Organizational Quality Management Program

PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE – 1 PORT DRIVE

PRESENTED TO

City of Nanaimo

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EXECUTIVE SUMMARY

Tetra Tech EBA Inc. (Tetra Tech) was retained by the City of Nanaimo (the City) to provide geotechnical and environmental investigation and review services for the proposed Events Centre location option, situated on a portion of 1 Port Drive.

This report presents the results of the background information review, geotechnical exploration, comments, and preliminary geotechnical and environmental recommendations related to the proposed site location and future development. The work was carried out in general accordance with Tetra Tech's work plan and cost estimate issued in November 2016

Based on the findings of the study, the key issues and considerations for the future proposed Event Centre are as follows:

Geotechnical

- *Settlement:* The overburden soils this site are highly variable comprising largely coal waste fill and other dredged material. The performance of these soils would be inconsistent over an area the size of the proposed sports complex and therefore specialized foundation options and/or ground improvement considerations would be required.
- *Liquefaction Potential:* Even where fill is not encountered, marine sediments (i.e., silty sands) are generally loose to compact and could liquefy during a seismic event.
- *Depth to Competent Bedrock:* Highly fractured bedrock was encountered near surface with residual soil/coal underlying it before competent bedrock was encountered. This could require piles to be advanced deep into bedrock for competent bearing and lateral restraint.
- *Coal Workings:* Although not mapped directly below the proposed sports complex, the area was heavily involved in the industrial mining industry and anecdotal evidence has suggested an unmapped mine shaft could exist near the northern edge of the building. Therefore, coal mines could extend under the site.
- *Existing Utilities:* The City has a main sanitary sewer alignment thought the area of the proposed structure.

If this development is to proceed, it is recommended that a detailed geotechnical site exploration be carried out to assist with detailed design. Although the exact scope would need to be established after further structural design details are known, it is expected that a detailed geotechnical explorations would include a minimum of:

- Cone Penetration Testing, which will help determine the risk of liquefaction and potential flowslide failure occurring at this site;
- Additional bedrock coring; and
- Investigation of the potential sinkhole area from the unmapped mine shaft.

Environmental

- *Soil and Groundwater Management:* Due to the presence of elevated hydrocarbon concentrations and chromium contamination in soil, any excess overburden fill soils requiring excavation and offsite removal will require proper quality screening and final onsite or offsite management, as per the British Columbia Contaminated Sites (CSR). Groundwater contamination was not identified, however, consideration for the analysis and potential for disposal of any excavation seepage water, if required, should be considered.

- *Soil Vapour Considerations:* Due to presence of coal waste with elevated hydrocarbon concentrations and potential methane issues, the potential for soil vapour migration into the proposed building should be considered.

- *Regulatory and Permitting:* Since 1 Port Drive has had a long history of CSR Schedule 2 industrial activities on it, all proposed future development related approval applications will trigger a requirement that a Site Profile be submitted with any new permit application, which will be held up by the municipality until either a CSR legal instrument or a release from the BC Ministry of Environment under CSR Administrative Guidance (AG) #6 is obtained.

Environmental Investigations completed to date are considered to accurately characterize the soil, soil vapour and groundwater quality in the proposed development locations. Therefore, no further subsurface environmental investigation work is recommended prior to the start of site development. A qualified environmental consultant, however, should be retained to assist in obtaining AG# 6 permit releases and during development activities to assist in the management of soils and groundwater and to collect confirmatory soil samples from the limits of any required construction excavations. The AG # 6 permit process would require a completion of a conceptual Remediation Plan that will be sufficient for a Contaminated Sites Approved Professional to provide a written opinion confirming that all the requirements set out under Scenario 5 of AG#6 for a Site Profile release can be met and the proponent can also feel comfortable stating in writing that the parcel will be remediated in accordance with the Remediation Plan.

We emphasized in our past remedial options report and further reiterate in this letter that reducing the volume of excavated soils that require offsite disposal would be a significant cost benefit to the City and/or any future site developer. The volume of excess soils (and potentially groundwater requiring management) generated requiring offsite disposal and the potential for reuse of such materials at the proposed development location or within another area of 1 Port Drive is wholly dependent on the final design of the proposed development. Therefore, to limit potential future environmental issues and costs, any future conceptual design plan should be reviewed by a qualified environmental consultant with contaminated sites experience to provide input on specific ways to limit and manage any excess fill soils and groundwater seepage that are generated from future construction works that will require offsite removal and also present options for following the recommended risk management approach (using a site specific Screening Level Risk Assessment) to develop the site in the future.

Any future building design plans should be reviewed by a qualified environmental consultant with CSR vapour assessment experience and also a HVAC specialist to provide input on the potential for vapours to be present at levels exceeding the BC CSR commercial land (CL) use standards that could infiltrate into the building and if so, present specific options for limiting intrusion of any vapours (including methane) into any future structures, by using standard construction methods such as vapour barriers and/or passive or active venting systems

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the City of Nanaimo and their agents. Tetra Tech EBA Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the City of Nanaimo, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA Inc.'s Services Agreement. Tetra Tech's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech) was retained by the City of Nanaimo (the City) to provide geotechnical and environmental investigation and review services for the proposed Events Centre location option, situated on a portion of 1 Port Drive. The location of the proposed Events Centre is shown on Figure 1.

This report presents the results of the background information review, geotechnical exploration, comments, and preliminary geotechnical and environmental recommendations related to the proposed site location and future development. The work was carried out in general accordance with Tetra Tech's work plan and cost estimate issued in November 2016.

2.0 SCOPE OF WORK

In the scope of work issued to the City on November 18, 2016, Tetra Tech proposed to carry out the following to support the combined geotechnical and environmental study:

- Background review of all readily available borehole and mining data within the proposed development location for geotechnical and mining information;
- Review of all existing soil, groundwater, vapour analytical data available for the proposed development location to assess for the presence/absence of impacted soil and groundwater or other environmental issues that would need to be physically remediated and/or risk managed prior to or during development;
- Plot any remaining soil, groundwater and/or vapour that have concentrations of contaminants that exceed the BC Contaminated Sites Regulation (CSR) standards on to-scale site plans within the proposed development footprint;
- A geotechnical exploration consisting of coring four testholes to depths of up to 5 m into competent bedrock to assess the depth to bedrock, slope of the bedrock surface, and the bearing capacity of the rock; and
- A materials testing laboratory program that will include Unconfined Compressive Strength tests on select samples of rock core.

The results of the background review, soil, groundwater, vapour analytical data review, investigation and laboratory program was to be provided in this preliminary geotechnical and environmental report. The report was to include:

- Conceptual foundation (i.e., pile) design based on the findings of the investigation including expected depth / slope of bedrock surface, expected bearing capacity of the rock, potential for rock anchoring and rock socket design;
- Potential construction issues and recommendations dealing with the overburden soils (i.e., coal mine waste and marine sediments);
- Other potential considerations for construction at this site will be generally discussed (e.g., seismic stability on sloping bedrock);
- Outline any environmental remediation and/or risk management requirements and provide some preliminary cost ranges for such so that the development as a Sports Entertainment Complex could proceed and meet with BC CSR requirements; and,

- Identify the typical environmental requirements that will be triggered under the CSR to allow all future municipal development applications to be approved such as obtaining releases under CSR Administrative Guidance 6 (AG6) or another CSR process such as obtaining a legal instrument, if required.

3.0 SITE DESCRIPTION

The proposed development is located at a portion at 1 Port Drive in Nanaimo, BC and is situated on the south side of Nanaimo's downtown core, just south of Port Place Mall. Proposed Event Center location is developed with asphalt paved parking and laydown area as infrastructure supporting Seaspan commercial ferry services. Figure 1 shows the general site location.

The site is gently sloping from an elevation of about 6 m above mean sea level (asl) near Front Street down to about 3.5 m asl on the eastern side towards the waterfront. The area was former marine foreshore that has been filled over time and has a long history of mining and industrial development, as previously detailed in Tetra Tech's 2012 geotechnical report[1] for a portion of 7 Port Way and Tetra Tech's 2014 historical environmental report for 1 Port Drive[2].

4.0 PROPOSED EVENTS CENTRE

It is understood the proposed Events Centre structure on the portion of 1 Port Drive is in the developmental stage and that schematic plans are currently being prepared. Tetra Tech has received some of the schematic plans from Brisbin Brook Beynon Architects (dated October 14, 2016) and understand the following regarding a proposed structure:

- The structure will be approximately 7200 m^2 in area and equivalent to 4 stories high;
- The structure will be a combination of trussed steel portal frames with glass paned cladding;
- An ice rink will be situated in its centre with 5,700 occupancy concert style seating;
- Club areas and private suites will be located at 3rd and 4th levels;
- A Concourse perimeter will be located on the ground floor with washrooms, food concessions, and ticketing; and
- The Events Centre will also include an entry plaza and exterior service area.

It is likely that this structure would be classified as a post disaster building of high importance to the City and therefore, maintaining serviceability after a severe seismic event would be a performance requirement.

5.0 BACKGROUND AND DESKTOP STUDY

The following past geotechnical and environmental reports were referenced as background information for the proposed development location:

[1] Tetra Tech (EBA A Tetra Tech Company), Preliminary Geotechnical Assessment Report – Portion of 7 Port Way, Nanaimo, BC, (2012), File V13103082-01

[2] Tetra Tech (Tetra Tech EBA), Stage 1 Preliminary Site Investigation, 1 Port Drive, Nanaimo, BC, (2014), File ENVIND03511-01

- Tetra Tech (EBA A Tetra Tech Company), Preliminary Geotechnical Assessment Report – Portion of 7 Port Way, Nanaimo, BC, (2012), File V13103082-01;
- Tetra Tech (Tetra Tech EBA), Stage 1 Preliminary Site Investigation, 1 Port Drive, Nanaimo, BC, (2014), File 704-ENVIND03511-01; and
- Tetra Tech (Tetra Tech EBA), Detailed Site Investigation, 1 Port Drive, Nanaimo, BC, (2015), File 704-ENVIND03511-01.

We note that Tetra Tech's 2012 preliminary geotechnical assessment of a portion of 7 Port Way encompassed the current 1 Port Drive address location, which was created by the City after the report was issued. The past reports include the findings from a desktop study of historic environmental testhole data, historic coal working data, site reconnaissance and additional subsurface geotechnical and environmental investigation works.

5.1 Site History

Tetra Tech's understanding of the site is that all of the Nanaimo assembly wharf area, including Port Way, was reclaimed in the early 1900's. Historically, the area was extensively mined for coal and has a long history of industrial activity. A plan showing the coal mining areas is provided on Figure 2. As industrial development increased in the area, the shoreline was modified with dredge fills from the Nanaimo Harbour, coal mining waste and other fills. The original shoreline, as mapped in 1891, is shown on Figure 2. The majority of the filling at the site predates the earliest aerial photographs obtained from 1947. This filling likely was completed by end dumping of coal waste and other industrial fill materials and/or hydraulic placement of dredged marine sands. In the 1950s, 1 Port Drive was developed into the Wellcox yard for the loading and transportation of freight by rail, truck and marine ferries, which is the primary activities that continue up to the present day.

5.2 Coal Mining

Available underground coal workings maps indicate that the proposed location of the Events Centre has not been undermined with coal workings. However, the maps indicate nearby areas of 1 Port Drive have undergone mining activities and the accuracy of these maps cannot completely rule out possible coal mining activities within the proposed development location.

As mentioned in the 2012, 7 Port Way report, verbal discussions with Seaspan personnel suggest that a large opening existed near the proposed Event Centre locations. Anecdotally, the feature opened as a large sinkhole, with cedar beams exposed, and was backfilled and paved over. The approximate location of this feature, based on verbal discussion, is sketched on Figure 2. As available mining records did not indicate any shafts in this area, it is possible that this feature is an unrecorded mine shaft or an old bridge, trestle, or culvert, possibly leading to Cameron Island.

5.3 Site Geology, Hydrogeology and Previous Environmental Testholes

- Past reports indicate that 1 Port Drive is primarily underlain by coal waste and imported fill overlying native marine sediments with only some small areas that were original ground. The fill types were summarized as follows:
- Fill type 1: Sand, either homogenous, or sandy silt, with some gravel and no coal waste.
- Fill type 2: Mixed coal waste - silt, sand and gravel with occasional construction debris, brown and black (< 50% coal).

- Fill type 3: Coal waste, silt, sand and small gravel, black (50% to 100% coal).
- Fill type 4: Mixed gravel, silt and sand (no coal to traces of coal).

Combined fill thickness in the area of the proposed development location ranged from 2.2 m to 6.5 m with an average thickness of 4.3 m. Fill type 1 was found at an average thickness of 1 m. Fill type 2 was found at an average thickness of 1.9 m. Fill type 3 was found at an average thickness of 1.4 m. Fill type 4 was found at an average thickness of 2.9 m.

Groundwater was found to be present within fill soils. At high tide on September 22, 2014, the depth to groundwater ranged from about 2.4 m to 4.9 m below grade, with an average depth of about 3.9 m below grade. Groundwater identified at 1 Port Drive in an unconfined fill hydrostratigraphic unit is tidally influenced.

Site geology and hydrogeology was investigated in a number of previous environmental studies at the proposed development location and surrounding area which have been reviewed as part of this study. The following environmental testhole studies were reviewed:

- Jacques Whitford Environment Limited, April 29, 1996 report “Environmental Site Assessment, Interlink Terminal No. 755, Nanaimo, BC”;
- GeoViro Engineering Ltd., June 1998 report “Phase II Environmental Site Investigations – 21 Esplanade Street, Nanaimo, BC”;
- GeoViro Engineering Ltd., March 2001 report “Phase II Environmental Site Investigation – Wellcox Yard, Nanaimo, BC”;
- SNC Lavalin Environment, June 26, 2009 report “Comprehensive Environmental Site Investigation – CPR Wellcox Yard, Nanaimo, BC”: and
- Tetra Tech EBA Inc., November 2015 report “ Detailed Site Investigation – 1 Port Drive, Nanaimo, BC”

Although the environmental testholes were not logged with specific geotechnical data as a focus, testholes in proximity to the proposed development location (generally within 50 m of the building footprint) have been included as Appendix D with this report with their locations shown on Figure 3.

5.4 Review of Past Analytical Data

Historical and current use of the proposed development location has the potential for resulting in contamination. The past environmental studies investigated all areas of potential environmental concern and identified soil contamination in the fill soils in the area of the proposed development location. The locations of the testholes and the soil analytical results are shown on the attached Figures 6a, 6b and 6c. Fills soils within the Event Centre footprint were found to have chromium concentrations exceeding the CSR commercial land use (CL) standards, which is the applicable land use for the proposed development. A number of the test holes contained chromium concentrations in soils exceeding the CSR CL use standards but met the background concentration for Vancouver Island. These locations are shown in blue on the attached figure 6a. Locations with chromium concentrations exceeding both the CSR CL standards and the background concentration for Vancouver Island are shown on the attached Figure 6a in red. The horizontal extent of the chromium contamination in soils was determined during Tetra Tech’s 2015 DSI and shown on the attached Figure 6a, however, it should be noted, due to the non-homogenous characteristic of the fill, there is a potential for pockets of coal waste with elevated chromium levels throughout the proposed development location. The vertical extent of the chromium contamination in soils appears to be dependent

on the thickness of the coal waste fill across 1 Port Drive. Generally the soil chromium contamination appears to be limited to the top 2.5 m depth below grade with only a few isolated exceptions showing deeper fill depths. We estimated that the average depth of chromium contamination in coal waste fill soil using all the data obtained is approximately from surface to 2.0 m below grade.

The highest recorded concentration of chromium (140 µg/g) was noted at SNC Borehole BH09-2, located near the proposed development location, at a depth of 0.8 to 0.9 mbgs. This is located within the Seaspan lease area near the marine docking area where historical coal loading was completed in the past. The sample containing the highest concentration of chromium during Tetra Tech's 2015 DSI (14BH04-2 at 138 ug/g) was submitted for toxicity characteristic leaching procedure (TCLP) to determine if the chromium was leachable and/or could be classified as a hazardous waste. The TCLP test results indicated the chromium leachate concentration was below the hazardous waste regulation (HWR) standard. In addition, eight samples containing the highest chromium concentrations from across 1 Port Drive, exceeding the Protocol 4 background values were also submitted for synthetic precipitation leaching procedure (SPLP) to determine if chromium identified in the coal waste fill soils would leach at concentrations greater than the applicable CSR aquatic life water use (AW) standard. The SPLP test results indicated that the concentrations for chromium in all the leachate tests were below the specific CSR AW standard. This finding indicated that the chromium exceedances in soils identified on 1 Port Drive, could not leach into groundwater at levels exceeding CSR AW standard and potentially impact the downgradient marine aquatic biota receptor, thus this pathway was deemed incomplete. The SPLP findings were backed up by the fact that no groundwater contamination from chromium was identified at or near the proposed Event Centre to date. Therefore, it was concluded in Tetra Tech's EBA 2015 DSI report that even though there were fill soils with identified with chromium concentrations exceeding the CSR CL standards, this material could either remain in place or be reused onsite during future development through the use of a Screening Level Risk Assessment (SLRA) and a risk management program. We note, however, that if any of the fill soils identified with chromium concentrations exceeding the CSR CL standards have to be removed from legal boundaries of 1 Port Drive, they would have to be managed according to the CSR and disposed of an authorized waste soil facility.

Soils tested within and in the immediate surrounding area of the proposed Event Centre contained concentration of hydrocarbons and volatiles less than the applicable CSR CL Standards. However, concentrations of light and heavy extractable petroleum hydrocarbons; benzene, toluene, ethylbenzene and xylenes (BTEX) and Polycyclic Aromatic Hydrocarbons (PAHs) were detected at concentrations exceeding the CSR Schedule 7 standards, which would trigger the need for a soil relocation agreement (SRA) if any of these soils had to be relocated offsite to non-agricultural lands. This is significant for any soils that may meet CSR CL standards but exceed the CSR Schedule 7 limits and require offsite relocation in order to complete the development. No groundwater contamination for any of the parameters tested has been identified at or near the proposed Event Centre to date. Two soil vapour probes were installed in the area of the proposed development location (SV07 and SV08). The soil vapour results from both these two probes showed benzene concentrations exceeding the CSR vapour standard before attenuation was applied. However, once the attenuation factors based on future at grade buildings were applied, the calculated benzene concentration in vapour met the CSR CL standards for both indoor and outdoor air.

6.0 SITE EXPLORATION

Based on Tetra Tech's knowledge and discussions with the project team, the geotechnical exploration program was focused on identifying the depth to bedrock and bedrock quality. Mr. Andrew Walker, P.Eng., and Ms. Cori Creba, EIT, were onsite to conduct the exploration program, which consisted of advancing four testholes into bedrock for core sample retrieval. The program began on November 21, 2016, and was completed on November 24, 2016. Drillwell Enterprises Ltd. was the drilling contractor, operating out of Duncan, BC.

6.1 Rock Coring

At all four testhole locations, casing was advanced through the overburden to establish the depth to bedrock. The overburden was not logged as the focus of the study was on bedrock depths and characteristics. Coring of the bedrock was completed using HQ coring in Testholes BH16-01 to BH16-03 and NQ coring was utilized in BH16-04. Due to difficult drilling in BH16-03, NQ coring was advanced through the HQ drill pipe at a depth of 13.7 m, in order to complete the testhole. Coring was advanced to termination depths between 15.6 m and 17.4 m below ground surface.

Rock cores were retrieved and transferred into core boxes to be logged, photographed and transported to Tetra Tech's Nanaimo lab for review and UCS testing.

6.2 Laboratory Testing

The rock strengths were classified in accordance with the Canadian Geotechnical Society's "Canadian Foundation Engineering Manual" (2006), which rates rocks from Grade R0 (Extremely Weak) to Grade R6 (Extremely Strong). One of the guides for classifying the rocks is the Uniaxial Compressive Strength (UCS) test. A total of six samples of the rock core (cut to a length of approximately twice the core diameter) were tested in Tetra Tech's laboratory to assess the UCS. The results are included on the borehole logs in Appendix B and provided below in Table 1.

Table 1: Summary of Laboratory Tests on Bedrock Samples

Testhole	Rock Type	Location			Uniaxial Compressive Strength, UCS (MPa)	Rock Grade
		Depth from Ground Surface (m)	Depth from Bedrock Surface (m)	Elevation (m asl)		
	SANDSTONE	-8.9	-2.5	-3.9	26.4	R3
BH16-02	SANDSTONE	-9.1	-2.8	-4.2	67.0	R4
BH16-02	SILTSTONE	-16.6	-10.3	-11.7	21.3	R2
BH16-04	SANDSTONE	-4.9	-1.2	0.6	70.8	R4
BH16-04	SANDSTONE	-6.5	-2.8	-1.0	69.1	R4
BH16-04	SILTSTONE	-10.4	-6.7	-4.9	22.8	R2

7.0 SUBSURFACE CONDITIONS

7.1 Overburden Soils

Five testholes from the previous environmental exploration are located within the proposed Events Centre footprint as shown on Figure 3. All five testholes encountered coal waste intermixed with variable thicknesses and mixtures of silt, sand and gravel fill.

Table 2 below summarizes the five testholes directly in the proposed building footprint.

Table 2 – Summary of Previous Environmental Testholes within Building Footprint

Test Hole Number	Elevation (m)*	Depth to Native Soil (m)	Depth to Bedrock (m)	Termination Depth (m)	Test Hole Comments
14BH28	4.4	5.2	5.5	5.5	Varying SAND, SILT and GRAVEL (FILL) with coal waste to depths of 4.1 m, typically loose.
14BH/MW29	4.1	3.3	n/a	6.1	Varying SAND, SILT (FILL) with coal waste over GRAVEL, sandy, some silt. Bedrock depth not confirmed.
98-03	n/a	5.2	n/a	6.0	SAND (FILL), coal waste, some gravel, over SAND and GRAVEL
98-02	n/a	-	5.2	5.2	SAND and GRAVEL (FILL), some coal waste to possible bedrock at 5.2 m
09-3	4.3	-	4.6	4.6	Varying SAND, GRAVEL and COAL (FILL) with varying composition, loose to compact consistency.

*Elevations rounded to the nearest 0.1 m

Additional testholes in the vicinity of building footprint were reviewed for subsurface conditions and some have been used for section data in Figure 5 of this report. Historical testhole logs have also been included as Appendix D in this report.

Much of this site was historically occupied by the Nanaimo Harbour, and was gradually infilled with coal waste, dredged sand, and other fills in the late 1800s and early 1900s. This filling likely consisted of end dumping (of coal waste) or hydraulic placement (of dredged sand), with no (or limited) compaction completed. Due the local source of the sand fill materials, Tetra Tech expects that there was difficulty in determining if soils were fill or native material during previous studies, and there may be some inaccuracy in the reported depths of native materials.

7.2 Bedrock

The November 2016 exploration completed coring within the bedrock to depths between 15.4 m (BH16-01 and BH16-03) and 17.4 m (BH16-02 and BH16-04). The bedrock was generally strong to medium strong, moderately to highly fractured sandstone or siltstone in the upper metres. Bedrock generally varied between slightly weathered, light grey, strong sandstone rock to dark grey, highly weathered strong siltstone rock. Rock masses were generally very poor to fair quality near surface with thin laminations of silt and coal. The siltstone included lithology of severely to completely weathered rock to the point of residual soil condition. In general, the bedrock was initially competent in the upper 2 to 3 m, then would become a series of crushed zones, residual soil or coal for 1 to 3 m, prior to becoming competent bedrock again. Photographs of the rock coring runs are provided in Appendix C.

UCS testing was carried out on samples of each rock type, which resulted in UCS values of 67.0 MPa to 70.4 MPa for the sandstone rock, and 21.3 MPa to 22.8 MPa for the siltstone rock. An anomalous sandstone sample resulted a UCS value of 26.4 MPa which was likely due to the nature fractures already developed within the rock sample (which were observed after the specimen failure).

The bedrock surface generally dips down to the east at 10% (5.7°) in the area under the proposed building. North of the building, the bedrock swings to a more southeast dip. A contour drawing indicating the approximate depth to the surface of the bedrock and relative depth from ground surface, with reference to Chart Datum, is shown on Figure 4. The contours were developed using the geotechnical exploration conducted by Tetra Tech and previous environmental testholes completed by Tetra Tech and others where bedrock was encountered or inferred from refusal.

7.3 Groundwater

The latest measurements of groundwater monitoring wells were taken near high tide on September 22, 2014, as part of the Tetra Tech DSI study. Groundwater elevations ranged from -0.2 m to -0.6 m and are expected to be influenced by changing tides and precipitation levels.

8.0 KEY DEVELOPMENT ISSUES

Geotechnical

Based on the findings of the geotechnical study, the key issues which should be considered in the design of the proposed Event Centre are as follows:

- *Settlement:* The overburden soils this site are highly variable comprising largely coal waste fill and other dredged material. The performance of these soils would be inconsistent over an area the size of the proposed sports complex and therefore specialized foundation options and/or ground improvement considerations would be required.
- *Liquefaction Potential:* Even where fill is not encountered, marine sediments (i.e., silty sands) are generally loose to compact and could liquefy during a seismic event.
- *Depth to Competent Bedrock:* Highly fractured bedrock was encountered near surface with residual soil/coal underlying it before competent bedrock was encountered. This could require piles to be advanced deep into bedrock for competent bearing and lateral restraint.
- *Coal Workings:* Although not mapped directly below the proposed sports complex, the area was heavily involved in the industrial mining industry and anecdotal evidence has suggested an unmapped mine shaft could exist near the northern edge of the building. Therefore, coal mines could extend under the site.
- *Existing Utilities:* The City has a main sanitary sewer alignment thought the area of the proposed structure

Environmental

Based on the findings of the past environmental studies, the key issues which should be considered in the design of the proposed event centre are as follows:

- *Soil and Groundwater Management:* Due to the presence of elevated hydrocarbon concentrations and chromium contamination in soil, any excess overburden fill soils requiring excavation and offsite removal will require proper quality screening and final onsite or offsite management, as per the BC CSR. Groundwater contamination was not identified, however, consideration for the analysis and potential for disposal of any excavation seepage water, if required, should be considered.

- *Soil Vapour Considerations:* Due to presence of coal waste with elevated hydrocarbon concentrations and potential methane issues, the potential for soil vapour migration into the proposed building should be considered.
- *Regulatory and Permitting:* Since 1 Port Drive has had a long history of CSR Schedule 2 industrial activities on it, all proposed future development related approval applications will trigger a requirement that a Site Profile be submitted with any new permit application, which will be held up by the municipality until either a CSR legal instrument or a release from the BC MOE under CSR Administrative Guidance (AG) #6 is obtained.

8.1 Settlement

The fill soils at 1 Port Drive likely consist of end dumped coal waste or hydraulic placed dredged sand, with no (or limited) compaction completed. Surface loading from industrial activity has likely created a consolidated crust, overlying looser material below, which has performed reasonably well for the existing pavement subgrade and bearing conditions for small commercial office buildings (e.g., Seaspan office).

It is expected that, if high building loads were induced on the soil structure, further settlement could occur. Additionally to this, a seismic event could cause some densification of the soils and result in settlement even without liquefaction occurring.

Any foundation system, such as piles, needs to consider the possible differential settlement between the building and surrounding areas. If the building is constructed on piles, service connections and other utilities that are not constructed on piles will need to be designed to allow for some tolerance to potential settlement, especially if site grading is increased from existing elevations.

8.2 Coal Waste Fill

While ground improvement methods such as Rapid Impact Compaction (RIC) could likely improve the coal waste to provide good short and medium term performance, there is uncertainty regarding long term performance which suggests that the most effective method for dealing with the coal waste would be to use a structural pile foundation system. Due to the depth of bedrock at this site, RIC may not be able to improve all of the coal waste fill at this site.

8.3 Liquefaction Potential

Liquefaction can occur in loose to compact silts and sands below the water table, conditions that exist across much of the 1 Port Drive. Consequences of liquefaction includes; large lateral deformation (termed “lateral spread”) of the ground towards the ocean, settlement of the ground and foundations, floatation of buried utilities, manholes and potential failure of shallow foundations.

Further geotechnical exploration and detailed analysis would be required to determine the magnitudes of settlement and lateral spread. Based on the available information it is judged that a piled foundation and/or ground improvement techniques will be required to prevent damage to site features. Piles will have to be designed for potential lateral loads due to spreading.

8.4 Coal Workings

The portion of 1 Port Drive where the proposed Event Centre is located, has not been mapped as an area of coal workings, however, the maps cannot be fully relied upon and there is potential for workings in the vicinity of this location to extend beyond areas that have been mapped.

The depths of mine workings mapped in the area of 1 Port Drive range from 127 m (417 ft.) to 177 m (579 ft.) below sea level and, at this depth, would be considered low risk to surface features should subsidence occur. Further to this, based on the time elapsed since mining took place, these features are expected to be in poor condition and may have already collapsed or partially collapsed.

Tetra Tech expects that if subsidence due to mine working collapse were to occur, it would likely be triggered by an extreme seismic event. It is noted that these conditions exist in the vicinity of the proposed Event Centre location and may have some effect on parking areas or other site features.

Risk of subsidence below the proposed Event Centre structure would be considered low due to the depth of nearby workings.

Prior to development at this site, Tetra Tech recommends the reported opening along Front Street (as discussed in Section 4.2, and shown on Figure 2), is investigated and that the exact location, condition, and cause of this opening be determined, if possible.

8.5 Existing Utilities

It is understood that a 600 AC sewer main is aligned through the proposed Events Centre location and will require realignment prior to construction. It was also observed during utility locating that a large chamber exists in the proposed footprint that would likely need to be removed and relocated. An alternative option to moving the sewer main could include developing a foundation system to bridge the underground utilities and leave them in place. This would have to be explored with the structural engineer for this proposed development.

8.6 Piled Foundation System

Considering the presence of variable coal waste fill and potentially liquefiable soils, the proposed Events Centre structure would likely need to be supported on piles. The sloping bedrock also prescribes that the piles would need to be drilled into competent bedrock (rock socketed) to withstand lateral spread (flowslide) during a seismic event. To determine the soil reactions expected during design seismic events, the overburden soils would need to be characterized through a detailed geotechnical study utilizing CPT analysis.

Pile design is typically an iterative process with the structural engineer to develop preferred pile type and size, and assist in analyzing lateral pile load response. Preliminary axial pile capacity is discussed in the following section to assist in developing a preliminary pile design

The structure would require a structural slab capable of being fully supported between piles. Pile lengths could range from 12 m to 16 m across the site but would be subject to the final design grade of the building and final pile bearing loads. An inferred bedrock surface has been illustrated in Figure 4 and cross sections are shown on Figure 5.

8.6.1 Axial Pile Capacity of Pile Foundations

For preliminary design purposes, the axial capacity of a drilled pile was estimated using the provisions of Canadian Foundation Engineering Manual[3]. According to this method, the allowable load on the pile was calculated as $q_{allowable} = K_{sp}.\sigma_c$, where;

- $q_{allowable}$ is the allowable bearing pressure with a factor of safety of 3.0 included.
- K_{sp} is an empirical coefficient, taken as 0.1 considering that the discontinuities within the bedrock are closely spaced.
- σ_c is the average unconfined compressive strength of the rock core, selected to be 25 MPa considering the weathering of the bedrock near the interface with the overlying soils.

Using the above parameters, the allowable bearing pressure of 2.5 MPa was estimated for piles drilled a minimum of 3 m into competent bedrock. It should be noted that in some cases, drilling a pile deeper into a higher quality rock formation can allow for higher bearing capacities, which can make for a more efficient pile design. As a pile design progresses, discussions with the structural engineer can help determine the most economical depth for pile spacing.

All loads should be designed for end bearing in bedrock with no skin friction being applied.

8.7 Entry Plaza and Exterior Service Area

These areas may not be subject to a significant increase in loading of the subgrade soils and therefore settlement would be likely be minimal and could be dealt with by designing the areas using materials that can be easily relevelled such as pavers.

Additional to this, some localized ground improvement such as nominal excavation and replacement with clean structural fill could be completed to help reduce potential settlement issues relates to the variable fill materials.

8.8 Pavement and Parking

The entire site is suitable for use as parking areas as this is consistent with the current use of much of the site. Surface loading from industrial activity has likely created a consolidated crust, overlying looser material below. This is observed in the existing paved areas which have performed reasonably well under heavy loads and turning stresses associated with the Seaspan loading operations. Areas that are currently gravelled have also likely experienced similar consolidation of underlying materials, but with no paved surface, it is harder to establish a good performance indicator. Construction and maintenance of the existing pavement and laydown areas has likely induced much of the primary settlement issues related to pavement structures and operation which may have already been experienced and remedied.

For development of a good parking surface, a properly designed pavement structure is required, which is normally based on the strength of the upper meter of soil on site. On this site, the upper materials are generally granular fill, which can be graded and compacted to form a good subgrade on which a parking structure can be placed. However depending on final grades, coal waste could be encountered when developing an adequate subgrade. The coal

[3] Canadian Foundation Engineering Manual, (2006). 4th edition published by The Canadian Geotechnical Society c/o BiTech Publishers Ltd., Vancouver.

waste is expected to act as a granular material and, if adequate compaction can be achieved, it is expected to perform adequately in the short term for supporting road pavement loads. Long term performance is not known. It is suspected that the coal particles may break down under repeated impacts (such as those imposed by vehicles travelling over the waste on a roadway). This material breakdown would likely manifest itself in the form of additional settlement.

For these uses a well-designed surface drainage system is required to ensure proper runoff of storm water, and prevent ponding of water. In the areas where the grade is to be raised, this will be an additional load which can cause some consolidation of the lower soils, so in this case, it is important to consider some possible settlement of the surface when designing the surface drainage.

Any surfacing or pavements used at the site should consider the possibility of settlement:

- If hard surfaced with concrete, later movements can result in cracking and poor surface run off conditions, which leads to water ponding and reduced performance.
- Asphalt pavement is more flexible, and can undergo some movements without severe cracking but the same disruption of surface runoff will occur resulting in the possibility of ponded water and poor performance.
- Staging a properly designed gravel surface could be an alternative option to allow for design grade settlements to occur and remediated prior placing final asphalt or other surface pavement finish.
- Higher loading areas such as bus parking may need to have some special pavement consideration and design.

8.9 Soil and Groundwater Management

A review of the analytical data obtained from past environmental reports indicate that soils requiring excavation would require proper management as follows:

- Any excess soils suspected of exceeding CSR CL standards and requiring offsite disposal will have to be sampled tested at a frequency of 1 sample per 250 m^3 to satisfy CSR Technical Guidance 1 requirements for characterization before disposal;
- Any soils found after testing known to exceed the CSR Schedule 4 and 5 soil standards and CSR Schedule 7 relocation standards that require offsite disposal should be transported to an appropriate disposal facility; and,
- If groundwater is required to be managed during construction, the seepage water would need to be tested and a suitable disposal location would need to be determined.

Removal of excess soil based on the geotechnical design considerations in this letter is estimated at 5000 m^3 (or estimated 9000 tonnes) which includes a bulking factor of 1.2; removal of 0.5 m from the building foundation area; removal for pile driving and removal for underground utility upgrades and connections. Based on analytical data collected to date, we expect approximately 50% of this material could exceed commercial land use standards or CSR Schedule 7 relocation standards.

The following table provides an assessment of potential remediation costs taking into consideration all geotechnical design requirements and having to manage any identified contaminated fill soils requiring excavation and offsite disposal during future development activities. The costs also include completing a SLRA to address all remaining soil contamination within the proposed development location, after all excavation works have been completed.

Area of Environmental Concern (AEC)	*Estimated Total Volumes of Impacted Soils > CSR CL	**Estimated Costs/Tonne	Estimated Total Costs – Waste Contractor	***Estimated Total Costs – Consulting
AEC 1: Coal Waste/Mixed Fill	*2500-4500 tonnes ex-situ	$120/tonne	$300-500K	$50-75K

Table Notes: *estimated impacted soil volumes only that are based an assumption that there will be soils present in fill layers on at least ½ of the Property with Cr or other parameters exceeding CSR CL or Schedule 7 standards that cannot be managed or reused either onsite or on another area of 1 Port Place during construction and will require offsite disposal at costs/tonne listed.

**Estimates based on $/tonne listed in table provided by Quantum in 2016 which are subject to change. Includes excavation, loading, hauling and disposal.

*** Estimates includes all consulting fees including completing of A SLRA after development has been completed, lab testing costs and all other disbursements. Costs do not include costs for obtaining permits and/or legal instrument. This is discussed in Section 8.11.

We point out to the City that the potential environmental remediation costs listed in the above table are considered the worst case scenario, since the total volume of impacted soils can be reduced if any or all the excavated fill soils can be reused either on the proposed development site or another area located within the legal boundaries of 1 Port Drive, instead of being removed offsite for disposal (see Section 9.0 for more details).

8.10 Soil Vapour Considerations

Fill soils at the proposed development location contained elevated hydrocarbon levels in vapour at concentrations exceeding the CSR CL soil vapour standards, before attenuation factors were applied. Once the attenuation factors were applied, as documented in our 2015 DSI report that assumed at grade buildings, the calculated vapour concentrations were below the CSR CL soil vapour standards for both indoor and outdoor air.

8.11 Regulatory and Permitting

The primary impediment facing any owner/proponent that wishes to re-develop a contaminated property in BC is that it normally will require that either a formal release from normal CSR requirements or a legal instrument (such as a Certificate of Compliance (CofC)) be issued from the BC Ministry of Environment (MOE) so that the local municipality are legally able to issue certain municipal development approvals. The primary trigger in this process is the Site Profile (Schedule 1 of BC CSR) which has to be submitted to the municipality for most land development related approvals or permits since they are tied in with the BC CSR, with only a few exceptions. Once a municipality receives such an application they check to see if the Site Profile submitted indicates that there were any industrial or commercial (CSR Schedule 2) activities on a site, and if there were they are then obligated to pass the Site Profile onto the BC MOE for review and comment. Once the BC MOE reviews the Site Profile they will issue a standard letter back to the municipality which states that the proponent must obtain either a CSR legal instrument or a release from the CSR under the provisions of Administrative Guidance Document #6 (AG#6) of the CSR, before the municipality can release any rezoning, subdivision, development permits and other approvals.

Since the property has had a long history of CSR Schedule 2 industrial activities on it, all proposed future development related approval applications will trigger a requirement that a Site Profile be submitted with any new permit application which will be held up by the municipality until either a CSR legal instrument or a release from the BC MOE under CSR AG#6 is obtained. We recommend that that City of Nanaimo or any other proponent obtain releases from the Site Profile process requirements under CSR AG#6 to complete their proposed redevelopment plans which will allow for the approval of future municipal applications such as for subdivision approval and all other development related permits and meet all outstanding environmental investigation and remediation requirements over time, as outlined in following Section 9.0. The releases should be obtained in stages. That is the application for subdivision, if possible, should not occur until after development had been completed to allow for options for reuse of fill material on other areas of 1 Port Drive. Obtaining releases for permits under CSR AG#6, would allow for a development permit to be issued much sooner and at much lower cost than pursuing a CofC, since the 2014 Stage 1 PSI and 2015 DSI reports have already been completed so only a future Remediation Plan will be required to complete the application to the BC MOE. A release under AG#6 is normally issued to the proponent within a couple of weeks and allows the development permit to be approved by the Municipality immediately and construction to commence, without having to complete any immediate remediation. Under this approach, if any remediation and/or management of suspect impacted soils, soil vapour and/or groundwater is required, it could all be completed in conjunction with the development plan, under the Independent Remediation option of the CSR and the process generally does not require having to obtain a CofC at the completion of all remediation and/or risk management works.

9.0 FURTHER INVESTIGATION

Geotechnical

If this development is to proceed, it is recommended that a detailed geotechnical site exploration be carried out to assist with detailed design. Although the exact scope would need to be established after further structural design details are known, it is expected that a detailed geotechnical explorations would include a minimum of:

- Cone Penetration Testing, which will help determine the risk of liquefaction and potential flowslide failure occurring at this site;
- Additional bedrock coring; and
- Investigation of the potential sinkhole area from the unmapped mine shaft.

Environmental

Environmental Investigations completed to date are considered to accurately characterize the soil, soil vapour and groundwater quality in the proposed development locations. Therefore, no further subsurface environmental investigation work is recommended prior to the start of site development. A qualified environmental consultant, however, should be retained to assist in obtaining AG# 6 permit releases as per Section 8.11 of this report and during development activities to assist in the management of soils and groundwater and to collect confirmatory soil samples from the limits of any required construction excavations. The estimated environmental consulting costs during development activities are included in Section 8.9 of this report. The AG # 6 permit process would require a completion of a conceptual Remediation Plan that will be sufficient for a Contaminated Sites Approved Professional to provide a written opinion confirming that all the requirements set out under Scenario 5 of AG#6 for a Site Profile release can be met and the proponent can also feel comfortable stating in writing that the parcel will be remediated in accordance with the Remediation Plan.

Estimated costs and timeline to obtain a release from BC MOE for Development Permit and eventual Subdivision Permit is outlined in the table below:

Task #	Description of Item	Tetra Tech EBA Estimated Cost ($)	Approximate Schedule
1	Prepare letter and apply to BC MOE under AG#15 for release from delineation.	3K	0.25 months
8	Prepare a comprehensive Remediation/Risk Management Plan using findings of DSI and SLRA Feasibility study that follows a final development plan.	5K	0.5 months
9	Have a BC CSAP review all reports and Remedial Plan and apply to MOE for a release from CSR under AG#6.	3K	0.25 months
	ESTIMATED TOTAL COSTS/SCHEDULE	**11K**	**1 month**

We emphasized in our past remedial options report and further reiterate in Section 8.9 of this letter that reducing the volume of excavated soils that require offsite disposal would be a significant cost benefit to the City and/or any future site developer. The volume of excess soils (and potentially groundwater requiring management) generated requiring offsite disposal and the potential for reuse of such materials at the proposed development location or within another area of 1 Port Drive is wholly dependent on the final design of the proposed development. Therefore, to limit potential future environmental issues and costs, any future conceptual design plan should be reviewed by a qualified environmental consultant with contaminated sites experience to provide input on specific ways to limit and manage any excess fill soils and groundwater seepage that are generated from future construction works that will require offsite removal and also present options for following the recommended risk management approach (using a site specific SLRA) to develop the site in the future.

Any future building design plans should be reviewed by a qualified environmental consultant with CSR vapour assessment experience and also a HVAC specialist to provide input on the potential for vapours to be present at levels exceeding the BC CSR CL standards that could infiltrate into the building and if so, present specific options for limiting intrusion of any vapours (including methane) into any future structures, by using standard construction methods such as vapour barriers and/or passive or active venting systems.

10.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

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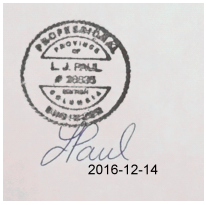

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FIGURES

Q:\Nanaimo\Engineering\ENW\.VENW03021-01 - 1 Port Way\VENV03021-01_R1.dwg [FIGURE 1] December 13, 2016 - 2:50:18 pm (BY: KITCHINGMAN, ISAAC)

0 500m

Scale: 1:10,000 @ 8.5"x11"

CLIENT

CITY OF NANAIMO
THE HARBOUR CITY

TETRA TECH EBA

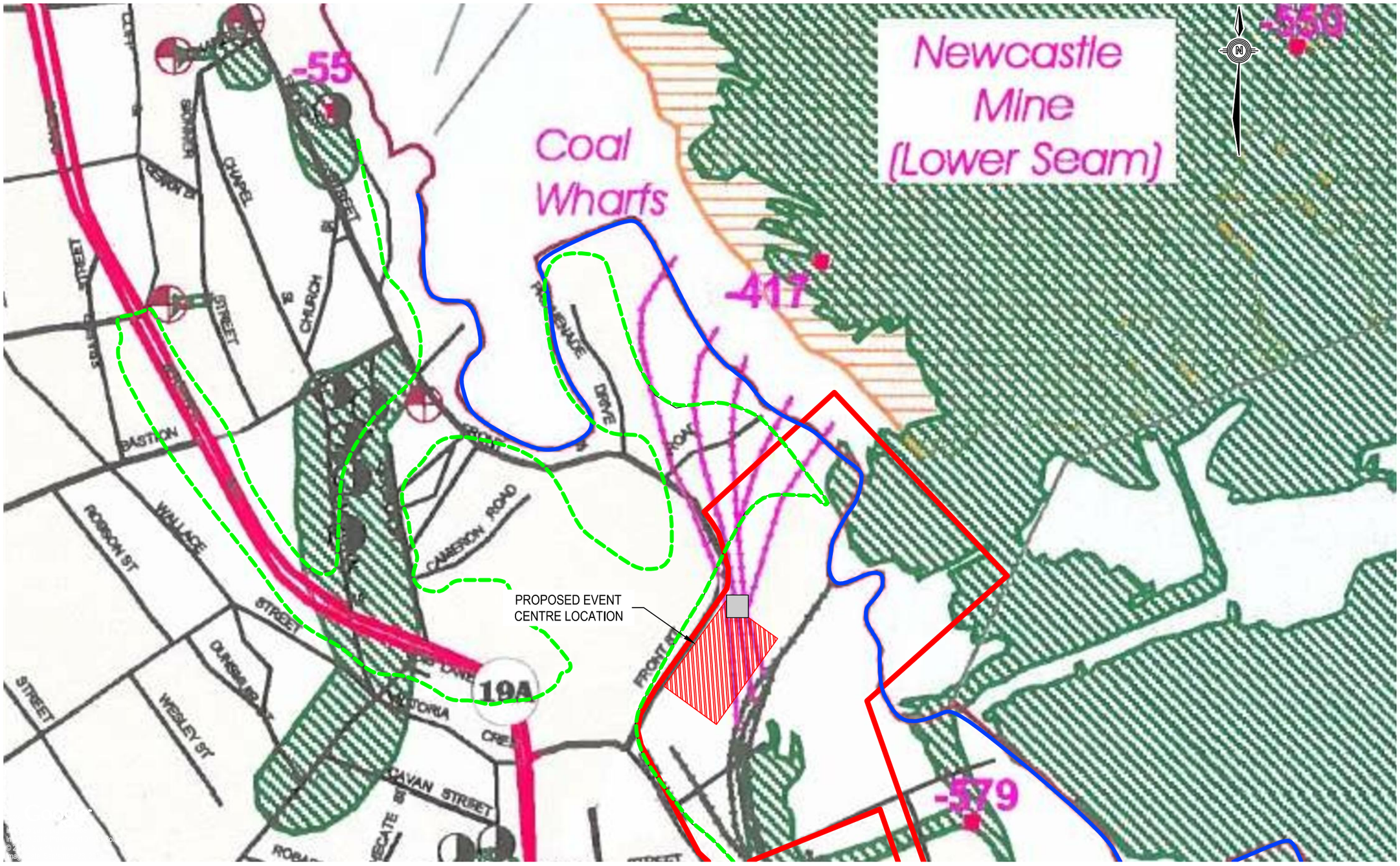
PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Site Location Plan

PROJECT NO.	DWN	CKD	REV
ENW03021-01	IK	AW	0

OFFICE	DATE
Nanaimo	December 8, 2016

Figure 1



Coal Mine Underground Workings

Legend

Roads
- Dirt Road
- Highway
- Landmarks (Bridge, Tunnel)
- Main Roads
- E & N Railway
- Roads
- Rough Road
- Transportation (Airport, Ferry)

Planimetric Features
- Mapsheet Boundary
- Coastline
- Rivers
- Wetlands
- Water Features

Lower Workings
- Underground Coal Mine Workings

Upper Workings
- Underground Coal Mine Workings
- Overlapping Workings

Shafts
- Entrance (Shaft)
- Entrance (Slope)
- -239 Spot Depth (Feet) Datum of Elevations: Geodetic B.M.'s
- Old Railway Routes

Map 9

N

The Mining Data is taken from several old data sources. Due to the lack of access to the mines and the possibility of unrecorded workings, the actual locations of the mine workings cannot be confirmed. This data is intended as a 'Guide' only and no responsibility relating to the locations of the mine workings can be accepted.

LEGEND

- 1 Port Way Property Boundary
- Current Shoreline (based off aerial imagery taken in 2009)
- Historic shoreline - circa 1881
- Possible location of reported opening - see text for discussion
- Old Railway routes
- Underground Coal mine workings
- (see legend in figure for further information)

ISSUED FOR USE

0 200m

Scale: 1:4,000 @ 11"x17"

NOTES:
Map as attained from Pacific Spatial Systems Ltd. "Coal Mine Underground Workings Atlas"

Historic shoreline as mapped from New Vancouver Coal Mining and Land Company, 1891, Map of the City of Nanaimo, BC, and City of Nanaimo animated map, "Then and Now - Evolution of Nanaimo's Downtown Waterfront, 1854-1997

Shorelines shown are scaled from google earth imagery and archived maps.This figure should be used only as a guide for the reader to have a general understanding of the shoreline changes with limitations of accuracy.

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PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Coal Mine Workings and Historic Shoreline Plan

TETRA TECH EBA

PROJECT NO.	DWN	CKD	REV
VENW03021-01	IK	AW	0

OFFICE	DATE
Nanaimo	December 8, 2016

Figure 2

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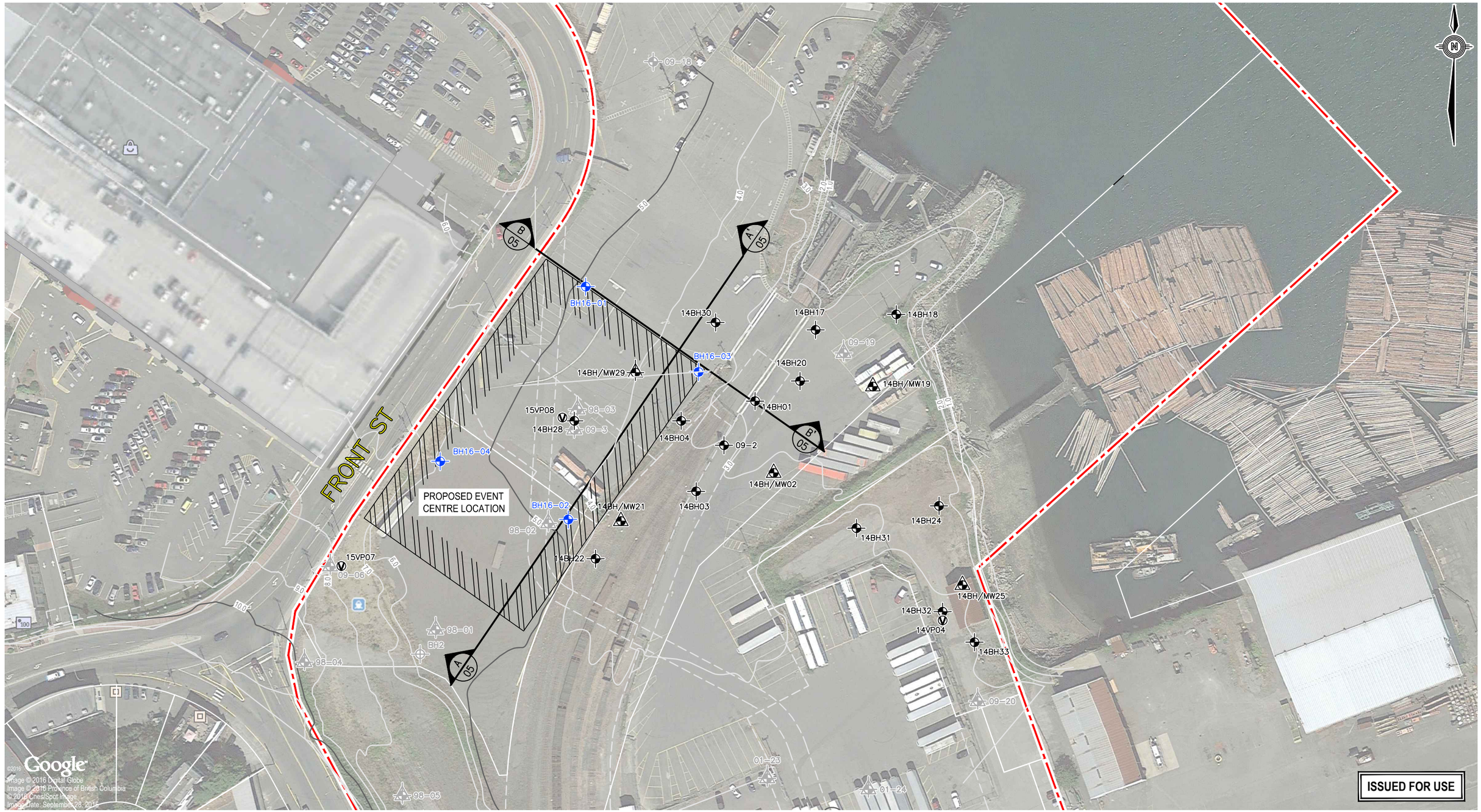

LEGEND

- 1 Port Way Property Boundary
- Rock Core Testhole Location
- Previous Environmental Testhole Location by Tetra Tech EBA
- Previous Environmental Testhole Location by Others
- Ground Surface Elevation Contour - 5 m
- Ground Surface Elevation Contour - 1 m

NOTES:
Previous environmental borehole and testpit locations (by others) attained from the drawing by SNC LAVALIN ENVIRONMENT "Inferred areas of Environmental Concern (SOIL) and estimated volumes > CSR IL/CL" - dwg # 133669-010B - 2009-06-10

Previous environmental testhole locations surveyed by the City of Nanaimo

2016 Geotechnical exploration rock core testhole locations from hand held GPS, elevations surveyed with level and staff and tied into 14BH/MW29 elevation.

0 50m

Scale: 1:1,000 @ 11"x17"

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PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

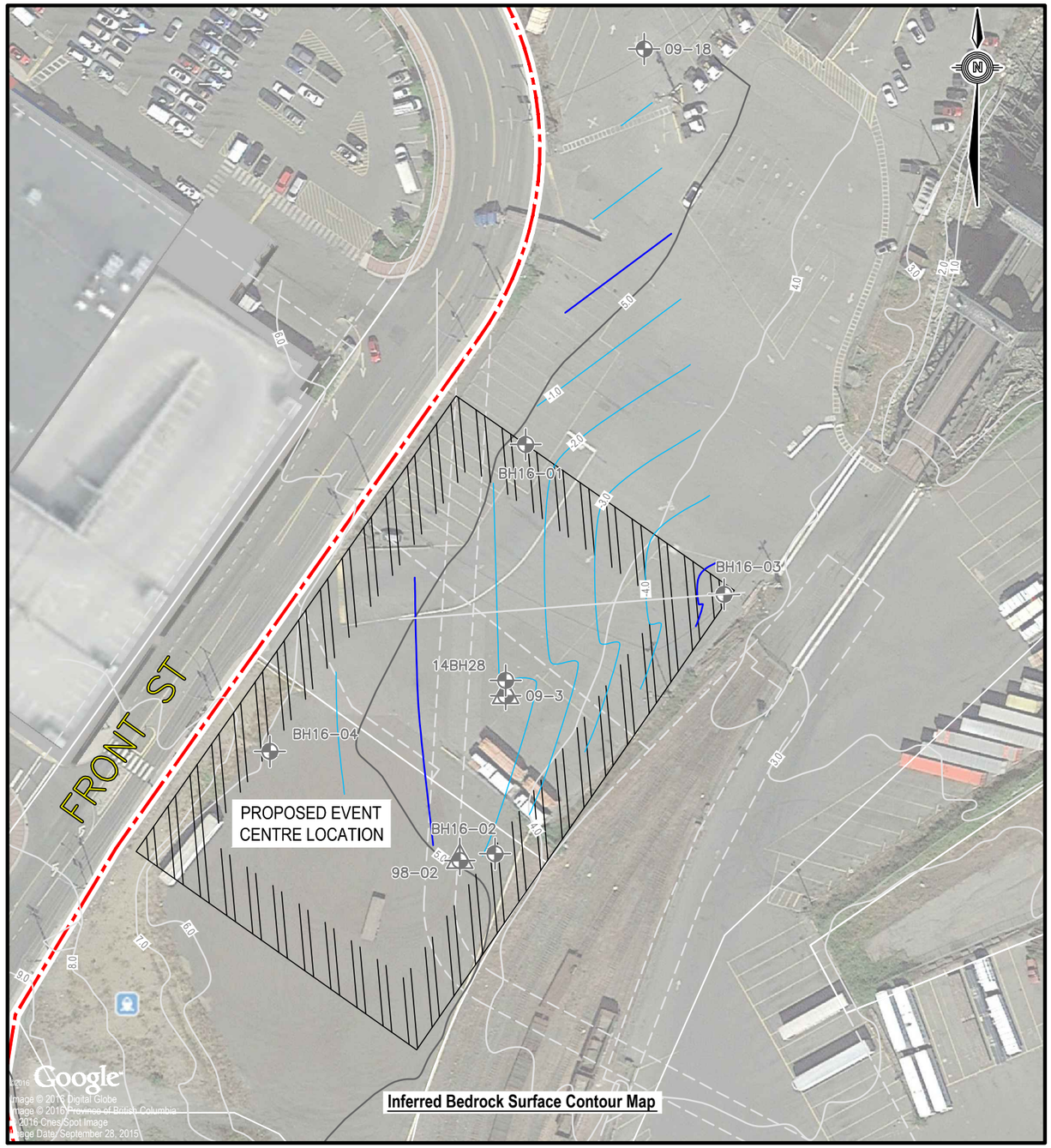
Testhole Location Plan

TETRA TECH EBA

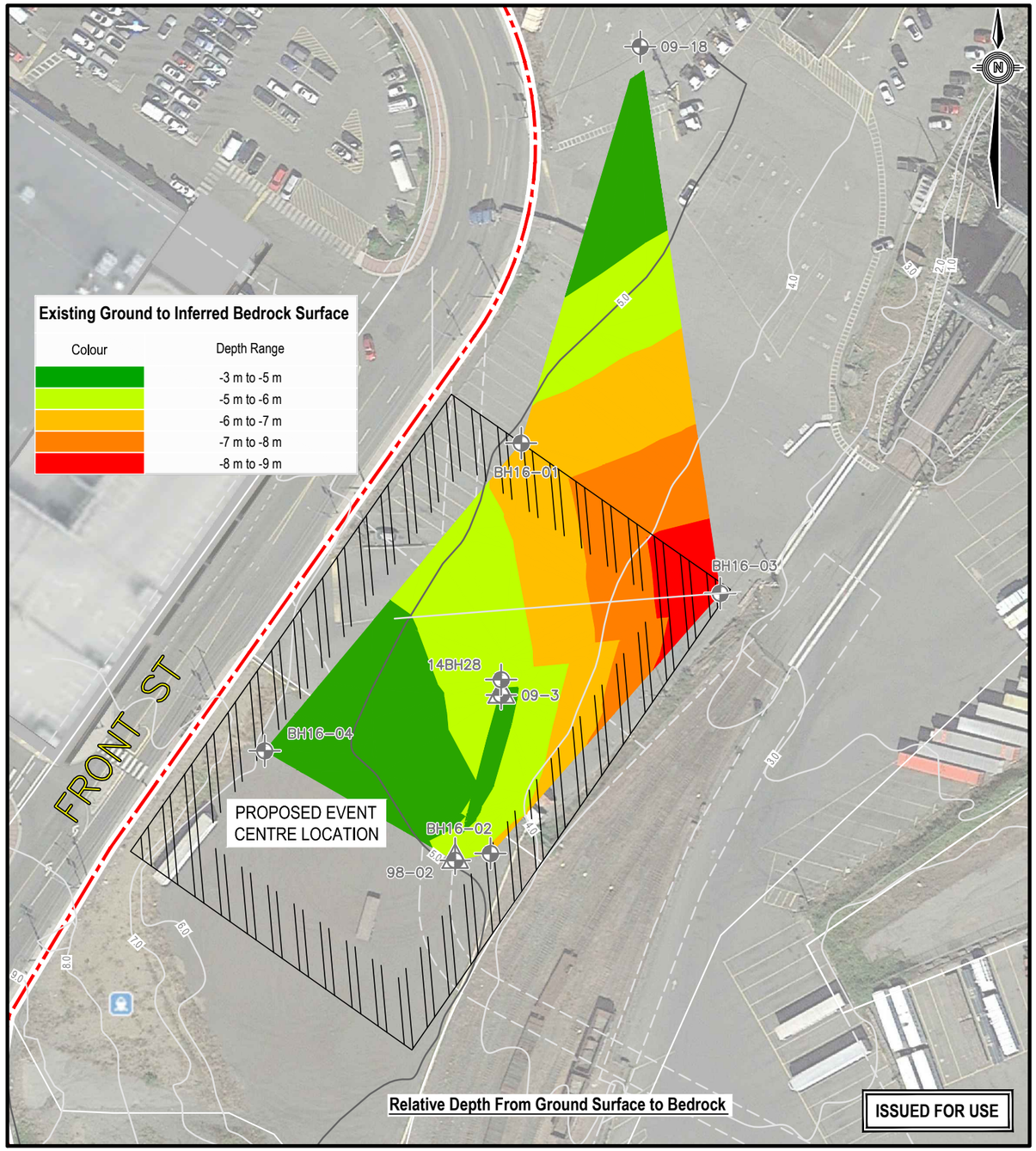
PROJECT NO.	DWN	CKD	REV
VENW03021-01	IK	AW	0

OFFICE: Nanaimo
DATE: December 8, 2016

Figure 3



Inferred Bedrock Surface Contour Map



Relative Depth From Ground Surface to Bedrock

ISSUED FOR USE

LEGEND

- 1 Port Way Property Boundary
- Testhole Location where Bedrock was Encountered or Inferred
- Inferred Bedrock Surface Elevation Contour - 5 m
- Inferred Bedrock Surface Elevation Contour - 1 m
- Ground Surface Elevation Contour - 5 m
- Ground Surface Elevation Contour - 1 m

NOTES:
Only testhole locations that encountered bedrock or encountered refusal on "inferred bedrock" have been shown for this figure for clarity.

0 50m

Scale: 1:1,000 @ 11"x17"

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PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Inferred Bedrock Surface and Relative Depth Contour Plans

PROJECT NO.	DWN	CKD	REV
VENW03021-01	IK	AW	0
OFFICE: Nanaimo	DATE: December 8, 2016		

Figure 4

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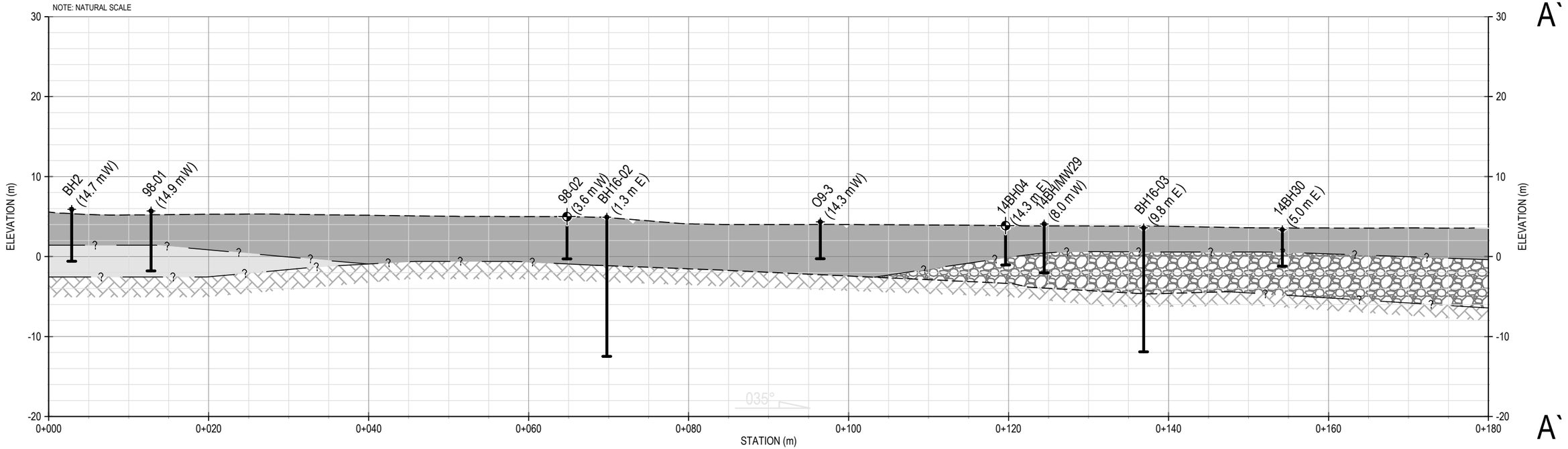
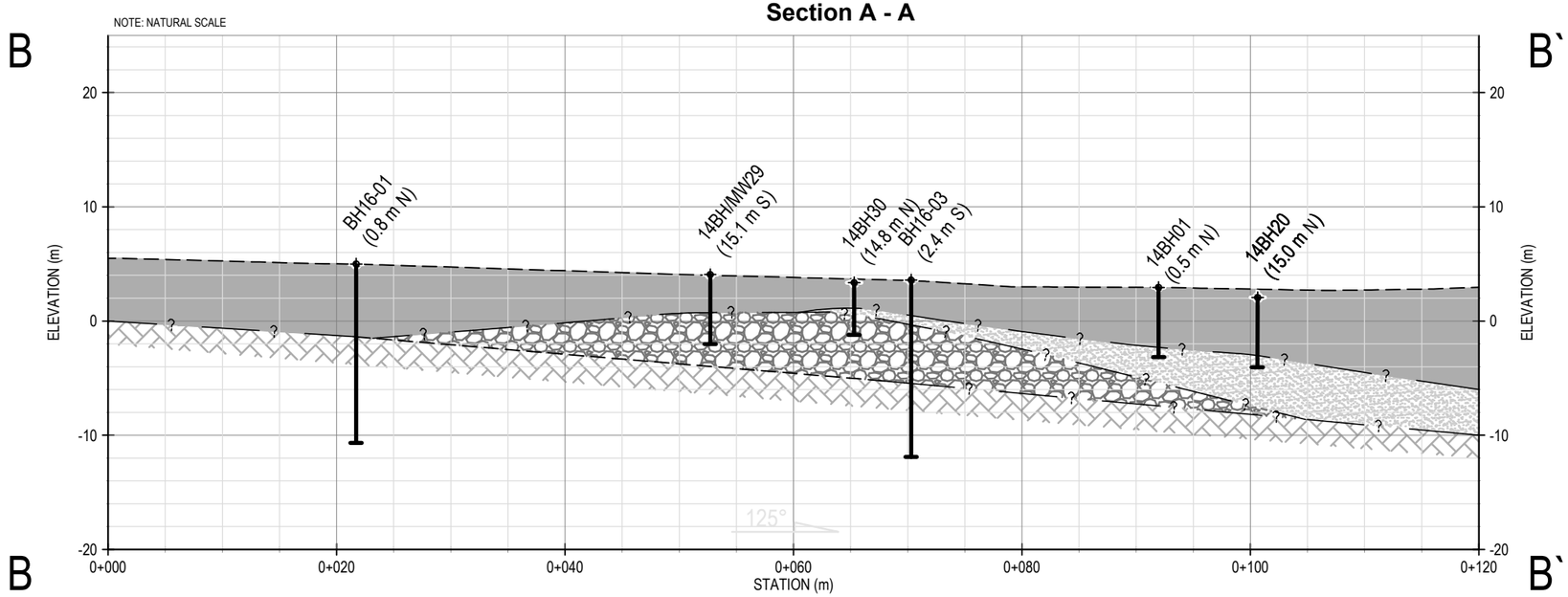


Section A - A



Section B - B

ISSUED FOR USE

LEGEND

- Testhole Location (metres offset and direction from section line)
- Mixed Coal Waste Fill
- GRAVEL - some silt, loose to compact (inferred)
- SAND, silty, loose to compact (inferred)
- BEDROCK

NOTES:
Soil conditions were interpreted at tested locations. These sections are to assist the reader in a general understanding of the stratigraphy across the site and it must be understood that actual subsurface conditions may vary from that shown.

0 25m
Scale: 1:500 @ 11"x17"

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PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Inferred Subsurface Conditions at Section A - A` and B - B`

PROJECT NO.	DWN	CKD	REV
VENW03021-01	IK	AW	0
OFFICE: Nanaimo	DATE: December 8, 2016		

Figure 5

Definitions	
AEC	Areas of Environmental Concern
APEC	Area of Potential Environmental Concern
COCs	Contaminants of Concern
PCOCs	Potential Contaminants of Concern
CSR	Contaminated Sites Regulation
CL and IL	Commercial and Industrial Land Use
HEPH	Heavy Extractable Petroleum Hydrocarbons
LEPH	Light Extractable Petroleum Hydrocarbons
EPH	Extractable Petroleum Hydrocarbons
PAHs	Polycyclic Aromatic Hydrocarbons
PCP	Pentachlorophenol
VOCs	Volatile Organic Compounds
VPH	Volatile Petroleum Hydrocarbons
AW	Marine Aquatic Life Water Use
BTEXS	Benzene, Toluene, Ethylbenzene, Xylenes, Styrenes

14BH20		Field ID	14BH20-1	14BH20-2	14BH20-3	14BH20-4	14BH20-5
		Sample Depth (m)	0.62 - 0.75	1.8 - 1.98	2.82 - 3.0	3.86 - 4.04	5.33 - 5.45
Parameter	Protocol 4	CSR CL/IL					
Chromium (hexavalent)	90	60	-	<1	-	<1	-
Chromium	90	60	109	115	81.6	96.8	77.1
Chromium (Trivalent)	90	95	-	115	-	96.8	-

14BH01		Field ID	14BH01-1	14BH01-2	14BH01-3	14BH01-5
		Sample Depth (m)	0.5 - 0.9	1.55 - 1.7	2.44 - 2.55	5.33 - 5.45
Parameter	Protocol 4	CSR CL/IL				
Chromium (hexavalent)	90	60	<1	-	-	-
Chromium	90	60	130	83.6	88.4	-
Chromium (Trivalent)	90	95	130	-	-	-

14BH04		Field ID	14BH04-2	14BH04-3	14BH04-4
		Sample Depth (m)	0.95 - 1.05	2.29 - 2.44	3.53 - 3.70
Parameter	Protocol 4	CSR CL/IL			
Chromium (hexavalent)	90	60	<1	-	-
Chromium	90	60	138	52.6	18.9
Chromium (Trivalent)	90	95	138	-	-

14BH28		Field ID	14BH28-2	14BH28-4
		Sample Depth (m)	0.8 - 0.95	3.88 - 4.0
Parameter	Protocol 4	CSR CL/IL		
Chromium	90	60	39.2	92.9

BH09-19				
Sample ID			BH09-19-2-090406	BH09-19-5-090406
Parameter	Protocol 4	CSR CL/IL		
Depth (mbg)	90	60	0.8 - 0.9	2.4 - 2.6
Chromium (µg/g)	90	60	80	93

14BH19		Field ID	14BH19-1	14BH19-3	DUP1	14BH19-4
		Sample Depth (m)	0.66 - 0.78	1.9 - 2.05		3.96 - 4.11
Parameter	Protocol 4 Background Values for Vancouver Island	CSR Schedule 4 & 5 - CL				
Chromium (hexavalent)	90	60	-	-	-	-
Chromium	90	60	15.4	65.9	35	81.9
Chromium (Trivalent)	90	95	-	-	-	-

BH09-2		Field ID	BH09-2-2-090406	BH09-2-5-090406
		Sample Depth (m)	0.8 - 0.9	2.3 - 2.4
Parameter	Protocol 4	CSR CL/IL		
Chromium (µg/g)	90	60	140	68

14BH02		Field ID	14BH02-1	14BH02-2	14BH02-3	14BH02-4
		Sample Depth (m)	0.65 - 0.75	1.15 - 1.27	2.15 - 2.3	2.5 - 2.67
Parameter	Protocol 4	CSR CL/IL				
Chromium (hexavalent)	90	60	-	1.3	-	-
Chromium	90	60	124	125	82	19.4
Chromium (Trivalent)	90	95	-	124	-	-

14BH31		Field ID	14BH31-1	DUPC	14BH31-4
		Sample Depth (m)	0.5 - 0.7		3.35 - 3.51
Parameter	Protocol 4	CSR CL/IL	11/13/2014	11/13/2014	11/13/2014
Chromium	90	60	109	102	15.2

14BH25		Field ID	14BH25-1	14BH25-2	14BH25-3	14BH25-4	14BH25-5
		Sample Depth (m)	1.05 - 1.25	1.85 - 2.1	2.72 - 2.84	3.73 - 3.85	5.65 - 5.80
Parameter	Protocol 4	CSR CL/IL					
Cadmium	0.35	2[#4]	4.23	4.77	0.207	0.462	-
Chromium (hexavalent)	90	60	-	-	-	<1	-
Chromium	90	60	-	46.7	-	123	99.7
Chromium (Trivalent)	90	95	-	-	-	123	-
Zinc	100	150[#4]	1460	1950	140	146	-

14BH33		Field ID	14BH33-5	14BH33-6
		Sample Depth (m)	4.27 - 4.42	5.74 - 6.02
Parameter	Protocol 4	CSR CL/IL		
Chromium	90	60	91.6	63.4

BC Contaminated Sites Regulation (CSR) (BC Reg. 375/96, including amendments up to BC Reg. 4/2014, January 31, 2014). The standards shown are the most stringent applicable CL/IL standards from CSR Schedules 4 and 10 (generic numerical soil standards) or CSR Schedule 5 (matrix numerical soil standards), considering the site specific factors of intake of contaminated soil, toxicity to soil invertebrates and plants, and groundwater flow to surface water used by marine aquatic life.

RED	Exceeds CSR CL/IL Standard and Protocol 4 Background Concentration
GREEN	Meets CSR CL/IL Standard
BLUE	Exceeds CSR Standard but below CSR Protocol 4 Background Concentration

ISSUED FOR USE

LEGEND

- 1 Port Way Property Boundary
- Borehole
- 1951 Historical Buildings (Approximate)
- 1957 Historical Buildings (Approximate)
- Monitoring Well Installed by others
- Test Pit Installed by Tetra Tech EBA
- Borehole & Monitoring Well Installed by Tetra Tech EBA
- Destroyed Monitoring Well
- Vapour Probe
- Inferred Extent of Chromium Contaminated Soils
- GREY Location Installed by others prior to 2009

0 50m

Scale: 1:1,250 @ 8.5"x11"

NOTE

LOCATIONS SHOWN ARE APPROXIMATE.

CLIENT

CITY OF NANAIMO
THE HARBOUR CITY

TETRA TECH EBA

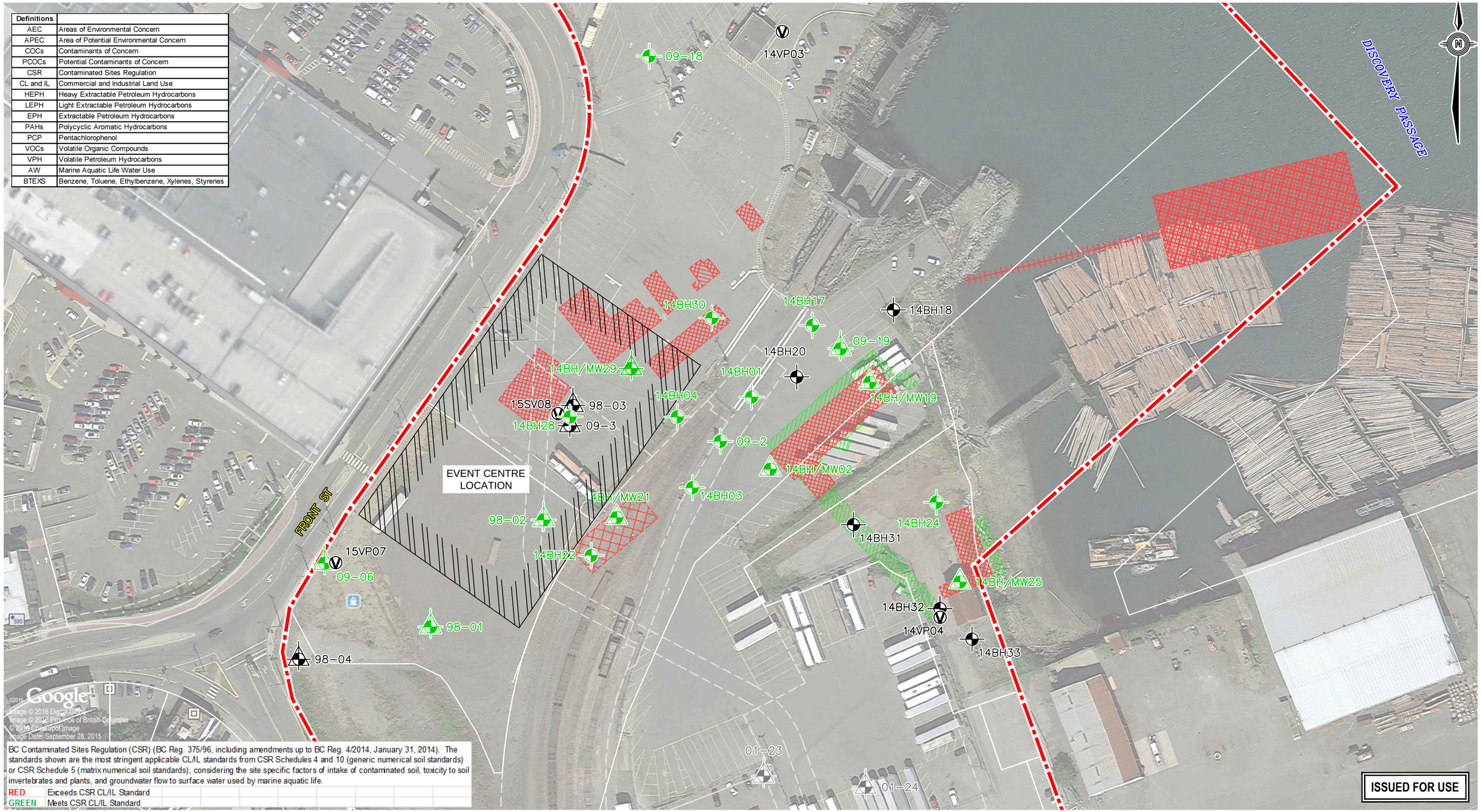
PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Summary of Soil Analytical Results - Metals

PROJECT NO.	DWN	CKD	REV
ENW03211-01	IK	LP	0
OFFICE: Nanaimo	DATE: December 8, 2016		

Figure 6a

Definitions	
AEC	Areas of Environmental Concern
APEC	Area of Potential Environmental Concern
COCs	Contaminants of Concern
PCOCs	Potential Contaminants of Concern
CSR	Contaminated Sites Regulation
CL and IL	Commercial and Industrial Land Use
HEPH	Heavy Extractable Petroleum Hydrocarbons
LEPH	Light Extractable Petroleum Hydrocarbons
EPH	Extractable Petroleum Hydrocarbons
PAHs	Polycyclic Aromatic Hydrocarbons
PCP	Pentachlorophenol
VOCs	Volatile Organic Compounds
VPH	Volatile Petroleum Hydrocarbons
AW	Marine Aquatic Life Water Use
BTEXS	Benzene, Toluene, Ethylbenzene, Xylenes, Styrenes



BC Contaminated Sites Regulation (CSR) (BC Reg. 375/96, including amendments up to BC Reg. 4/2014, January 31, 2014). The standards shown are the most stringent applicable CL/IL standards from CSR Schedules 4 and 10 (generic numerical soil standards) or CSR Schedule 5 (matrix numerical soil standards), considering the site specific factors of intake of contaminated soil, toxicity to soil invertebrates and plants, and groundwater flow to surface water used by marine aquatic life.

RED	Exceeds CSR CL/IL Standard
GREEN	Meets CSR CL/IL Standard

ISSUED FOR USE

LEGEND

- 1 Port Way Property Boundary
- Borehole
- 1951 Historical Buildings (Approximate)
- 1957 Historical Buildings (Approximate)

0 50m

Scale: 1:1,250 @ 8.5"x11"

- Monitoring Well Installed by others
- Test Pit Installed by Tetra Tech EBA
- Borehole & Monitoring Well Installed by Tetra Tech EBA
- Destroyed Monitoring Well
- Vapour Probe
- GREY Location Installed by others prior to 2009

NOTE

LOCATIONS SHOWN ARE APPROXIMATE.

CLIENT

CITY OF NANAIMO
THE HARBOUR CITY

TETRA TECH EBA

PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Summary of Soil Analytical Results LEPH, HEPH and/or PAHs

PROJECT NO.	DWN	CKD	REV
ENW03211-01	IK	LP	0
OFFICE: Nanaimo	DATE: December 8, 2016		

Figure 6b

Definitions	
AEC	Areas of Environmental Concern
APEC	Area of Potential Environmental Concern
COCs	Contaminants of Concern
PCOCs	Potential Contaminants of Concern
CSR	Contaminated Sites Regulation
CL and IL	Commercial and Industrial Land Use
HEPH	Heavy Extractable Petroleum Hydrocarbons
LEPH	Light Extractable Petroleum Hydrocarbons
EPH	Extractable Petroleum Hydrocarbons
PAHs	Polycyclic Aromatic Hydrocarbons
PCP	Pentachlorophenol
VOCs	Volatile Organic Compounds
VPH	Volatile Petroleum Hydrocarbons
AW	Marine Aquatic Life Water Use
BTEXS	Benzene, Toluene, Ethylbenzene, Xylenes, Styrenes

14BH/MW23
14VP03
09–18
DISCOVERY PASSAGE
14BH30
14BH17
14BH18
14BH20
14BH/MW29
14BH04
15VP08
98–03
14BH28
09–3
14BH/MW19
09–2
14BH/MW02
EVENT CENTRE LOCATION
14BH/MW21
14BH03
98–02
14BH22
14BH24
14BH31
15VP07
09–06
14BH/MW25
14BH32
14VP04
98–01
14BH33
98–04
09–20
01–23
01–24
FRONT ST
FRONT ST

BC Contaminated Sites Regulation (CSR) (BC Reg. 375/96, including amendments up to BC Reg. 4/2014, January 31, 2014). The standards shown are the most stringent applicable CL/IL standards from CSR Schedules 4 and 10 (generic numerical soil standards) or CSR Schedule 5 (matrix numerical soil standards), considering the site specific factors of intake of contaminated soil, toxicity to soil invertebrates and plants, and groundwater flow to surface water used by marine aquatic life.

RED	Exceeds CSR CL/IL Standard
GREEN	Meets CSR CL/IL Standard

ISSUED FOR USE

LEGEND

- 1 Port Way Property Boundary
- Borehole
- 1951 Historical Buildings (Approximate)
- 1957 Historical Buildings (Approximate)
- Monitoring Well Installed by others
- Test Pit Installed by Tetra Tech EBA
- Borehole & Monitoring Well Installed by Tetra Tech EBA
- Destroyed Monitoring Well
- Vapour Probe
- GREY Location Installed by others prior to 2009

0 50m

Scale: 1:1,250 @ 8.5"x11"

NOTE

LOCATIONS SHOWN ARE APPROXIMATE.

CLIENT

CITY OF NANAIMO
THE HARBOUR CITY

TETRA TECH EBA

PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Summary of Soil Analytical Results BTEXS, PH, VOCs and/or PHENOLS

PROJECT NO.	DWN	CKD	REV
ENW03211-01	IK	LP	0
OFFICE: Nanaimo	DATE: December 8, 2016		

Figure 6c

APPENDIX A

TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of TETRA TECH’s Client. TETRA TECH does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than TETRA TECH’s Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH’s instruments of professional service); only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by TETRA TECH shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of TETRA TECH’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except TETRA TECH. TETRA TECH’s instruments of professional service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

1.3 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.4 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.5 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.6 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of testholes and/or soil/rock exposures. Stratigraphy is known only at the locations of the testhole or exposure. Actual geology and stratigraphy between testholes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.7 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.8 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.9 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.10 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.11 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.12 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

1.13 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.14 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of the report, TETRA TECH may rely on information provided by persons other than the Client. While TETRA TECH endeavours to verify the accuracy of such information when instructed to do so by the Client, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

GENERAL CONDITIONS

GEO-ENVIRONMENTAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.1 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of TETRA TECH’s client. TETRA TECH does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than TETRA TECH’s Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the report, if required, may be obtained upon request.

1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH’s instruments of professional service); only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by TETRA TECH shall be deemed to be the original for the Project.

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Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

1.3 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.4 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of the report, TETRA TECH may rely on information provided by persons other than the Client. While TETRA TECH endeavours to verify the accuracy of such information when instructed to do so by the Client, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

2016 TESTHOLE LOGS

Borehole No: **BH16-01**

Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 5 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Ground Ice Description	Sample Type	Sample Number	▲RQD (%)▲ 40 60 80 100 / ■Recovery (%)■ 40 60 80 100	Backfill	Elevation (m)
0								5
	Advanced Casing	Limited cuttings available for observation - inferred coal waste - Casing advanced to bedrock						
6								-1
	HQ Coring	SANDSTONE, medium strong (R3), grey, fine grained, stained joints, moderately weathered (W3), very poor quality						
7		- 7.32 m to 7.57 m, highly fractured, recovered as gravel	7.4 m to 7.8 m - 80° to 90° IR, RO					-2
8		- 7.77 m to 7.87 m, highly fractured, recovered as gravel - highly weathered (W4), poor quality - strong (R4), moderately weathered (W3)	7.62 m - 20°, PL, RO 7.72 m - 20°, PL, RO 8.03 m - 2xJT, IR, RO 8.18 m - 2xJT, 0-10°, IR, RO			0		-3
9		- 8.48 m to 8.53 m, recovered as gravel - very strong (R5), slightly weathered (W2)	8.41 m -2xJT, 0-10°, IR, RO 8.53 m - 30°, PL, RO 8.76 m - 10°, PL, RO 8.94 m - 2xJT, 0-20°, IR, RO					-4
10		- good quality	9.35 m - 25°, PL, RO 9.55 m - multiple joints, crushed zone					-5

TETRA TECH

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 15.5 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 22
Logged By: CC	Completion Date: 2016 November 22
Reviewed By:	Page 1 of 2

Borehole No: **BH16-01**

Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 5 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Ground Ice Description	Sample Type	Sample Number	RQD (%) / Recovery (%)	Backfill	Elevation (m)
10								-5
11	HQ Coring	SILTSTONE, strong (R4), dark grey, slightly weathered (W2) - very poor quality - 11.01 m to 11.58 m, recovered as gravel - 11.58 m to 12.19 m, core loss - fair quality	9.75 m - 0-10°, IR, RO 10.12 m - 40°, IR, RO 10.21 m to 10.36 m - multiple joints, UN, RO Multiple joints, IR, RO 10.57 m - IR, RO 10.67 m to 10.82 m - multiple joints, IR, RO 10.90 m - 30-40°, IR, RO 11.02 m - 25°, PL, RO 11.02 m to 11.58 m - multiple joints, crushed zone 12.37 m - 20°, PL, RO 12.43 m - 0-10°, IR, RO 12.55 m- 10-30°, multiple joints, IR, RO 12.75 m - 2xJT, 20°, PL, RO 12.93 m - 10°, PL, RO 13.44 m to 13.659 m - 3xJTs, 40° to 75°, IR, RO 14.12 m - 0-10°, PL, RO 14.53 m - 25°, PL, RO 14.88 m - 30°, PL, RO 14.96 m - 25°, PL, RO 15.01 m - 20°, PL, RO 15.27 m - 15°, IR, RO 15.44 m - 15°, IR, RO			▲ RQD (%) ▲ 40 60 80 100 ■ Recovery (%) ■ 40 60 80 100		-6
12								-7
13					8			-8
14		SANDSTONE, strong (R4), grey, fine grained, slightly weathered (W2), very poor quality - good quality						-9
15								-10
16		End of hole at 15.5 m (target depth) - backfilled with bentonite to 0.5 m above bedrock - backfilled with cuttings and sand to surface Irregularities - Depth, Joints, Orientation, Type, Surface Condition JT = Joint IR = Irregular RO = Rough PL = Planar SM = Smooth UN = Undulating SL Slickenslides IF = Infilled						-11
17								-12
18								-13
19								-14
20								-15

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 15.5 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 22
Logged By: CC	Completion Date: 2016 November 22
Reviewed By:	Page 2 of 2

Borehole No: **BH16-02**

Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 4.9 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Ground Ice Description
0	Advanced Caing	Limited cuttings available for observation - inferred coal waste - Casing advanced to bedrock	
6.3	HQ Coring	SANDSTONE, strong (R4), grey, fine grained, massive, slightly weathered (W2),very poor quality - 6.3 m to 6.66 m, recovered as gravel	6.65 m - IF 6.81 m - 45°, PL, RO 6.93 m - 0°, IR, RO 6.93 m to 7.39 m, multiple joints, IR, RO 7.47 m - 0°, IR, RO 7.67 m - 2xJT, 0-10°, IR, RO 7.77 m to 8.38 m, multiple joints, completely weathered
7.67		- poor quality	
8.38		- 8.38 m to 8.78 m, core loss	
8.99			8.99 m - 45°, IR, RO
9.30			9.30 m to 9.75 m - multiple joints, IR, RO
9.85		- 9.85 m to 9.95 m, recovered as gravel, completely weathered (W5)	

Sample Type / Sample Number

▲RQD (%)▲ 40 60 80 100

■Recovery (%)■ 40 60 80 100

Backfill

Elevation (m): 4, 3, 2, 1, 0, -1, -2, -3, -4, -5

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 17.4 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 21
Logged By: CC	Completion Date: 2016 November 21
Reviewed By:	Page 1 of 2

TETRA TECH

Borehole No: **BH16-02**

Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 4.9 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Ground Ice Description	Sample Type	Sample Number	RQD (%) / Recovery (%)	Backfill	Elevation (m)
10	HQ Coring	- 9.95 m to 10.14 m, core loss	10.24 m to 10.31 m - multiple joints, SL and SM 10.57 m to 11.13 m - muliple joints, IR, RO 11.25 m - PL, SL 11.30 m - IR, RO 11.53 m - PL, SL 11.58 m - multiple joints, IR, RO		17	RQD (%) ▲ 40 60 80 100 ■ Recovery (%) ■ 40 60 80 100		-6
11								
12		- 12.04 m to 12.19 m, core loss - 12.19 m to 12.29 m, coal, fractured, completely weathered (W5) - 12.29 m to 13.11 m, core loss			0			-7
13		- 13.11 m to 13.29 m, recovered as gravel	13.32 m - 3xJT, 25-80°, IR, RO 13.46 m - 10°, PL, SM and JT, 100°, IR, RO					-8
14		SILTSTONE, strong (R4), black to dark gray, fine grained, slightly weathered (W2), very poor quality	13.61 m to 13.75 m - multiple joints, IR, RO 13.75 m to 14.02 m - multiple joints, IR, RO					-9
15		- 14.61 to 14.78 m, highly fractured - 15.23 m to 15.35 m, core loss - 15.47 m to 15.60 m, very weak (R1), highly weathered (W4), good quality	14.45 m - 40°, IR, RO 14.48 m - 25°, UN, SM 14.53 m - 25°, UN, SM 14.61 m to 14.78 m - multiple joints, IR, RO 14.87 m - 30°, PL, SM 14.92 m - 40°, IR, RO 15.70 m to 15.20 m, crushed rock zone 15.48 m - UN, SM 15.65 m - 50°, PL, RO 15.70 m - 50°, PL, RO 16.31 m - 0-5°, IR, RO 16.47 m - 0-5°, IR, RO 16.79 m - 0-20°, IR, RO 16.84 m - 10°, UN, SL 16.87 m - 10°, UN, SL 17.25 m - 10°, PL, RO					-10
16								-11
17								-12
18		End of hole at 17.4 m (target depth) - backfilled with bentonite to 0.9 m above bedrock - backfilled with cuttings and sand to surface Irregularities - Depth, Joints, Orientation, Type, Surface Condition JT = Joint IR = Irregular RO = Rough PL = Planar SM = Smooth UN = Undulating SL Slickenslides IF = Infilled						-13
19								-14
20								-15

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 17.4 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 21
Logged By: CC	Completion Date: 2016 November 21
Reviewed By:	Page 2 of 2

Borehole No: **BH16-03**

Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 3.6 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Ground Ice Description	Sample Type	Sample Number	▲RQD (%)▲ 40 60 80 100 / ■Recovery (%)■ 40 60 80 100	Backfill	Elevation (m)
0		Limited cuttings available for observation - inferred coal waste - Casing advanced to bedrock						3
1								2
2								1
3								0
4	Advanced Casing							-1
5								-2
6								-3
7								-4
8								-5
9		GRAVEL and COBBLES, rounded to subrounded						
10		SILTSTONE, strong (R4), dark grey, slightly weathered (W2), poor quality	9.22 m - IR, RO 9.32 m to 9.45 m, multiple JTs, discountinous, RO 9.50 m - 20°, PL, calcite IF 9.58 m - 20°, PL, calcite IF					-6

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 15.5 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 23
Logged By: CC	Completion Date: 2016 November 23
Reviewed By:	Page 1 of 2

Borehole No: **BH16-03**

Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 3.6 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Ground Ice Description	Sample Type	Sample Number	RQD (%) / Recovery (%)	Backfill	Elevation (m)
10								
11	Advanced Coring	- 10.06 m to 10.67 m, recovered as gravel - 10.67 m to 11.10 m, core loss - 11.10 m to 11.73 m, recovered as gravel	9.65 m - 20°, PL, calcite IF 9.70 m - 20°, PL, calcite IF 9.78 m - 2xJT, 20°, PL, RO 9.93 m - 30°, PL, SM 10.06 m - 30?°, PL, SM			0 0		-7 -8
12		- 12.00 m to 12.05 m, recovereed as gravel	11.84 m to 11.99 m, multiple JTs, IR, RO			0		-9
13		SILTSTONE and COAL, inferred from minimal recovery of core				8		-10
14		SANDSTONE, strong (R4), grey, fine grained, slightly weathered (W2)	14.33 m to 14.78 m, heavily jointed, gravelly/sandy					-11
15			14.88 m - JT, IR, RO 14.99 m - 2xJT, IR, RO 15.50 m to 15.54 m, multiple joints, IR, RO			6		-12
16		End of hole at 15.5 m (target depth) - backfilled with bentonite to 0.9 m above bedrock - backfilled with cuttings and sand to surface Irregularities - Depth, Joints, Orientation, Type, Surface Condition JT = Joint IR = Irregular RO = Rough PL = Planar SM = Smooth UN = Undulating SL Slickenslides IF = Infilled						-13
17								-14
18								-15
19								-16
20								

RQD (%): 40 60 80 100
Recovery (%): 40 60 80 100

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 15.5 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 23
Logged By: CC	Completion Date: 2016 November 23
Reviewed By:	Page 2 of 2

Borehole No: **BH16-04**

Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 5.5 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Comments	Sample Type	Sample Number	RQD (%) / Recovery (%)	Backfill	Elevation (m)
0	Advanced Casing	Limited cuttings available for observation - inferred coal waste - Casing advanced to bedrock						
1								
2		- possible fractured bedrock or boulders						
3								
4	NQ Coring	SANDSTONE, strong (R4), grey, fine, moderately weathered (W3), poor quality	3.74 m - 3xJT 65°, 10°, 85°, IR, RO 3.84 m - 2xJT 30°, 60°, IR , RO 4.01 m - 50°, PL, RO 4.19 m - 2xJT 80°, 90°, IR, RO 4.27 m - 60°, SL, PL 4.42 m - 45°, SL, PL 4.55 m - 2xJT 10°, 50°, SL, PL 4.80 m - 10°, IR, PL 4.86 m - 10°, RMR = 12, Jr = 1.5 5.08 m - 20°, RMR = 12, Jr = 3 5.23 m - 60°, PL, RO 5.41 m - 10°, PL, SM 5.64 m - 2xJT 55°, 10°, IR, RO 5.69 m - 10°, IR, RO 5.71 m - 10°, IR, RO 5.75 m - 10°, SL, PL 5.94 m - 10°, SL, IF 5.97 m - 2xJT 10°, 70°, IF 6.12 m - 20°, IR, RO 6.25 m - 35°, PL, SM 6.6 m - 20°, SL, IR 7.38 m - 2xJT 60°, 70°, IR, RO 7.43 m - 70°, SL, PL 7.55 m - 10°, IR, RO 7.85 m - 10°, SM, UN 7.90 m - 10°, IR, RO			15		
5		- 4.27 m to 4.42 m recovered as gravel						
6		- medium grained						
7		- good quality						
8		- 6.71 m to 7.35 m - core loss						
9		- medium strong, very poor quality						
10		- 8.07 m to 8.23 m recovered as gravel - fine grained, fair quality						
		SILT, some clay, black (0.08 m) SILTSTONE, weak (R2), dark grey, slightly weathered (W2), poor quality						

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 17.4 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 24
Logged By: CC	Completion Date: 2016 November 24
Reviewed By:	Page 1 of 2

Borehole No: **BH16-04**

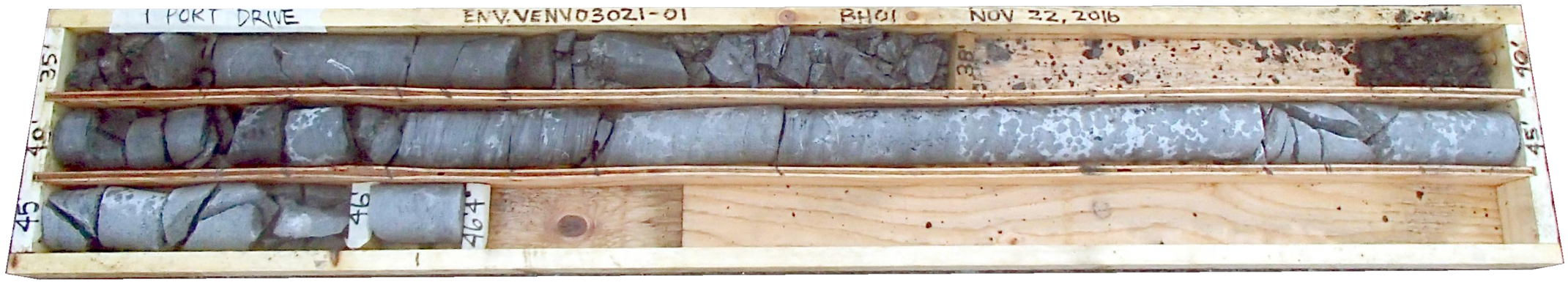
Project: Preliminary Geotechnical Options	Project No: ENW.ENW03021-01
Location: 1 Port Drive	Ground Elev: 5.5 m
Nanaimo	Issued for Use

Depth (m)	Method	Lithological Description	Comments	Sample Type	Sample Number	RQD (%) / Recovery (%)	Backfill	Elevation (m)
10						▲RQD (%)▲ 40 60 80 100 ■Recovery (%)■ 40 60 80 100		
		- medium strong	10.36 m - 10°, SM, UN					-5
			10.61 m - 15°, IR, RO					
11		- 10.77 m to 10.92 m core loss	10.82 m - 15°, IR, RO					
		- fresh, black, poor quality	11.28 m - 10°, PL, RO					-6
			11.78 m - 40°, PL, SL					
12			11.99 m - 65°, PL, SL					
			12.19 m - 20°, IR, SL					
			12.42 m - 4xJT 40°, 50°, 70°, 10°, PL, SL					-7
13	NQ Coring	SANDSTONE, extremely strong (R6), light grey, fine to medium grained, fresh (W1), good quality	12.90 m - 60°, PL, RO 13.05 m - 40°, IR, RO 13.07 m - 40°, IR, RO 13.29 m - 60°, PL, RO 13.46 m - 10°, IR, RO 13.61 m = 10°, IR, RO 13.72 m - 2xJT 10°, 20°, IR, RO					-8
14								
		- coal embedded in seam	14.54 m - 30°, PL, RO					-9
		- 14.70 m to 14.93 m - recovered as gravel	14.61 m - 30°, PL, RO 14.70 m - 30°, PL, RO 14.93 m 10°, IR, SL					
15								
			15.24 m 10°, PL, SL					-10
			15.61 m - 10°, PL, SL					
16		- excellent quality	15.85 m - 60°, PL, SO					
								-11
17								
		End of Hole at 17.4 m (target depth) - Hole backfilled with bentonite to 1 m above bedrock elevation - Backfilled to surface with cuttings and sand						-12
18								
		Irregularities - Depth, Joints, Orientation, Type, Surface Condition JT = Joint IR = Irregular RO = Rough PL = Planar SM = Smooth UN = Undulating SL Slickenslides IF = Infilled						-13
19								
								-14
20								

Contractor: Drillwell Enterprises Ltd.	Completion Depth: 17.4 m
Drilling Rig Type: Rock Core	Start Date: 2016 November 24
Logged By: CC	Completion Date: 2016 November 24
Reviewed By:	Page 2 of 2

APPENDIX C

ROCK CORE PHOTOGRAPHS



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CITY OF NANAIMO
THE HARBOUR CITY

TETRA TECH EBA

PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Rock Core Photos - BH16-01

PROJECT NO.	DWN	CKD	REV	
VENW03021-01	IK	AW	0	Appendix C1
OFFICE: Nanaimo	DATE: December 8, 2016			

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PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Rock Core Photos - BH16-02

PROJECT NO.	DWN	CKD	REV	
VENW03021-01	IK	AW	0	Appendix C2
OFFICE: Nanaimo	DATE: December 8, 2016			

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THE HARBOUR CITY

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PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Rock Core Photos - BH16-03

PROJECT NO.	DWN	CKD	REV	
VENW03021-01	IK	AW	0	Appendix C3
OFFICE	DATE			
Nanaimo	December 8, 2016			

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PRELIMINARY GEOTECHNICAL AND ENVIRONMENTAL ASSESSMENT OF POTENTIAL EVENT CENTRE DEVELOPMENT SITE - 1 PORT DRIVE

Rock Core Photos - BH16-04

PROJECT NO.	DWN	CKD	REV
VENW03021-01	IK	AW	0

OFFICE: Nanaimo

DATE: December 8, 2016

Appendix C4

APPENDIX D

PREVIOUS ENVIRONMENTAL TESTHOLE LOGS

Borehole No: **14BH/MW02**

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 3.13 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	14MW02	Elevation (m)
0	Solid stem auger	ASPHALT - (80 mm thick) SILT (FILL) - sandy, dry, loose, light brown				Top of casing elevation = 3.04 metres Monitoring well was set in a cement mixture at surface. Well was completed with 51 mm diameter PVC pipe, 10 slot (0.010") screen, end cap at the bottom, J-Plug at the top and is set inside a road box.		3
1		SAND (COAL WASTE FILL) - some silt, trace to some gravel, fine to coarse grained sand, damp to moist, loose, dark brown to black		2-1				
				2-2				2
2		- sticky, moist to wet		2-3				1
		SAND - silty, fine grained, saturated, mixed grey and black layers		2-4				
Sept22/14 3								Sept22/14 0
4				2-5				-1
		END OF BOREHOLE (4.57 metres) water - 2.87 metres below ground level at 17:34 on September 22, 2014 Monitoring well installed to 4.57 metres Note: All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)						-2
5								
6								-3
7								-4
8								-5
9								-6
10								-7
11								-8
12								

TETRA TECH EBA

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 4.57 m
Drilling Rig Type:	Start Date: 2014 September 15
Logged By: MG	Completion Date: 2014 September 15
Reviewed By: CM	Page 1 of 1

Borehole No: **14BH/MW19**

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 2.6 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	14MW19	Elevation (m)
0								
1	Solid stem auger (with Hollow stem ream)	ASPHALT - (80 mm thick) SILT (FILL) - sandy, trace gravel, fine grained sand, damp, soft, light brown and brown		19-1 19-2		Top of casing elevation = 2.51 metres Monitoring well was set in a cement mixture at surface. Well was completed with 51 mm diameter PVC pipe, 10 slot (0.010") screen, end cap at the bottom, J-Plug at the top and is set inside a road box.		2
2		SAND (COAL WASTE FILL) - silty, fine to medium grained, moist, loose, black		19-3				1
Sept22/14 3		SAND - trace to some gravel, coarse grained sand, saturated, dark brown						Sept22/14 0
4				19-4				-1
5		END OF BOREHOLE (4.57 metres) water - 2.33 metres below ground level at 17:26 on September 22, 2014 Monitoring well installed to 4.57 metres Note: All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)						-2
6								-3
7								-4
8								-5
9								-6
10								-7
11								-8
12								-9

TETRA TECH EBA

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 4.57 m
Drilling Rig Type:	Start Date: 2014 September 15
Logged By: MG	Completion Date: 2014 September 15
Reviewed By: CM	Page 1 of 1

Borehole No: **14BH/MW21**

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 3.47 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	14MW21	Elevation (m)
0	Solid stem auger (with Hollow stem ream)	SILT, SAND AND GRAVEL (FILL) - dry, loose, brown, (300 mm thick)				Top of casing elevation = 3.26 metres Monitoring well was set in a cement mixture at surface. Well was completed with 51 mm diameter PVC pipe, 10 slot (0.010") screen, end cap at the bottom, J-Plug at the top and is set inside a road box.		3
1		SAND (COAL WASTE FILL) - silty, trace gravel, fine to coarse grained sand, damp, medium dense, brown, black and orange specks, trace coal waste		21-1				2
2		- some silt, some gravel, black, trace crushed brick		21-2				1
3				21-3				0
Sept22/14		SAND (FILL) - silty, coarse grained, saturated, soft, dark brown					Sept22/14	
4		SAND - some silt, fine grained, saturated, medium dense, light brown		21-4				-1
		- trace silt, grey						
5		END OF BOREHOLE (5.03 metres) water - 3.29 metres below grade level at 17:39 on September 22, 2014 Monitoring well installed to 4.88 metres Note: Stopped due to auger refusal on probable bedrock. Note: All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)						-2
6								-3
7								-4
8								-5
9								-6
10								-7
11								-8
12								

TETRA TECH EBA

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 5.03 m
Drilling Rig Type:	Start Date: 2014 September 19
Logged By: MG	Completion Date: 2014 September 19
Reviewed By: CM	Page 1 of 1

Borehole No: **14BH/MW29**

Project: DSI - 1 PORT DRIVE	Project No: ENVIND03511-01.004
Location: 1 PORT DRIVE	Ground Elev: 4.07 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	14MW29	Elevation (m)
0	Solid and Hollow stem auger	ASPHALT - (70 mm thick) SAND (COAL WASTE FILL) - some silt to silty, fine to medium grained, damp, medium dense, black - trace of silt, fine to coarse grained, loose, black and brown		29-1		Monitoring well was set in a cement mixture at surface. Well was completed with 152 mm diameter PVC pipe, 10 slot (0.010") screen, end cap at the bottom, J-Plug at the top and is set inside a road box.		4
1				29-2				3
2		SILT (FILL) - trace of sand, trace of gravel, damp, very stiff, brown and grey		29-3				2
3		SILT AND SAND (COAL WASTE FILL) - some gravel, moist, stiff, black and brown						1
4 Nov17/14		GRAVEL - sandy, some silt, fine to coarse gravel, saturated, sticky, dark brown		29-4				0 Nov17/14
5								-1
6				29-5				-2
7		END OF BOREHOLE (6.10 metres) water - 3.89 metres below ground surface on November 17, 2014 Monitoring well installed to 6.10 metres Note: All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)						-3
8								-4
9								-5
10								-6
11								-7
12								

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 6.1 m
Drilling Rig Type:	Start Date: 2014 November 13
Logged By: MG	Completion Date: 2014 November 13
Reviewed By: SS	Page 1 of 1

TETRA TECH EBA

Borehole No: **14BH01**

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 2.94 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0		ASPHALT - (90 mm thick)					
	Solid stem auger	SAND (FILL) - some gravel, fine to medium grained sand, damp, very loose, dark brown to black		1-1	■		
1							2
		- fine to coarse grained sand, damp to moist, black, coal fragments		1-2	■		
2							1
				1-3	■		
3		GRAVEL (FILL) - sandy, trace silt, medium grained gravel, saturated, medium dense, brown to black					0
				1-4	■		
4							-1
5							-2
		SAND - silty, fine grained, saturated, grey		1-5	■		
6							-3
		END OF BOREHOLE (6.10 metres) Note: All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)					
7							-4
8							-5
9							-6
10							-7
11							-8
12							-9

TETRA TECH EBA

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 6.1 m
Drilling Rig Type:	Start Date: 2014 September 15
Logged By: MG	Completion Date: 2014 September 15
Reviewed By: CM	Page 1 of 1

Borehole No: **14BH03**

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 3.26 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	ASPHALT - (135 mm thick) SAND (FILL) - silty, some gravel, fine to coarse grained sand, dry, loose, brown					3
1		SAND (COAL WASTE FILL) - silty, trace gravel, fine to coarse grained sand, damp, medium dense, black and brown		3-1	■		2
		- increased coal content		3-2	■		
2							1
		SILT (FILL) - sandy, some small gravel, fine grained sand, moist, soft, black		3-3	■		
3		SAND - gravelly, coarse grained sand, saturated, loose, dark brown - silty, fine grained sand, soft, light brown and grey		3-4	■		0
4		SILT - trace organics, moist to wet, soft, grey and brown		3-5	■		-1
5		END OF BOREHOLE (4.65 metres)					-2
6							-3
7							-4
8							-5
9							-6
10							-7
11							-8
12							

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 4.65 m
Drilling Rig Type:	Start Date: 2014 September 16
Logged By: MG	Completion Date: 2014 September 16
Reviewed By: CM	Page 1 of 1

Borehole No: **14BH04**

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 3.51 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	SILT (FILL) - some sand, trace gravel, dry, loose, brown, trace roots		4-1			3
1		SAND (COAL WASTE FILL) - some silt to silty, trace gravel, damp to moist, loose, brown and black		4-2			2
2							1
3		- moist		4-3			0
4		SAND AND GRAVEL (COAL WASTE FILL) - fine to coarse gained, moist to wet, black					-1
5		SAND - trace silt, homogeneous, fine grained, moist to wet, grey and light brown		4-4			-2
6		END OF BOREHOLE (4.57 metres)					-3
7							-4
8							-5
9							-6
10							-7
11							-8
12							

TETRA TECH EBA

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 4.57 m
Drilling Rig Type:	Start Date: 2014 September 16
Logged By: MG	Completion Date: 2014 September 16
Reviewed By: CM	Page 1 of 1

Borehole No: 14BH17

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 2.82 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0		ASPHALT - (75 mm thick)					
		SILT (COAL WASTE FILL) - sandy, some gravel, soft, mottled		17-1			
1				17-2			2
		SAND (COAL WASTE FILL) - trace to some silt, trace gravel, fine grained sand, moist, medium dense, black					1
2		SAND (FILL) - silty, some gravel, saturated, medium dense, dark brown to black		17-3			
	Solid stem auger						0
3							
		SAND - trace gravel, trace silt, medium grained sand, saturated, loose					-1
4				17-4			
		SAND AND GRAVEL - trace silt, saturated, loose, dark brown					-2
5							
				17-5			-3
6		END OF BOREHOLE (6.10 metres)					
7							-4
8							-5
9							-6
10							-7
11							-8
12							-9

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 6.1 m
Drilling Rig Type:	Start Date: 2014 September 15
Logged By: MG	Completion Date: 2014 September 15
Reviewed By: CM	Page 1 of 1

Borehole No: **14BH20**

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 2.93 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	ASPHALT - (70 mm thick) SAND (FILL) - some gravel, fine to medium grained sand, dry, loose, brown SAND (COAL WASTE FILL) - some silt to silty, some gravel, damp, medium dense, black and brown		20-1			2
1		SAND AND GRAVEL (COAL WASTE FILL) - some silt, dry, loose to medium dense, mottled, coal waste inclusions SAND (COAL WASTE FILL) - some silt, trace to some gravel, damp, loose, black					
2		- larger gravel		20-2			1
3		- silty, some gravel, saturated, dark brown, trace coal waste, mixed coal waste		20-3			0
4				20-4			-1
5		SAND - silty, saturated, brown		20-5			-2
6		END OF BOREHOLE (6.10 metres)					-3
7							-4
8							-5
9							-6
10							-7
11							-8
12							-9

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 6.1 m
Drilling Rig Type:	Start Date: 2014 September 16
Logged By: MG	Completion Date: 2014 September 16
Reviewed By: CM	Page 1 of 1

Borehole No: 14BH22

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 3.64 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	SILT AND SAND (FILL) - gravelly, dry, loose, brown					3
		CONCRETE SLAB					
1		SAND (FILL) - some silt, some gravel, fine to medium grained sand, damp, medium dense, light brown to tan		22-1			2
		SAND (COAL WASTE FILL) - some silt, some gravel, damp, medium dense, black		22-2			
2				22-3			1
3							
		SAND AND SILT (COAL WASTE FILL) - fine to coarse grained, saturated, soft, brown and black, trace coal waste		22-4			0
4		SAND - some silt, very fine grained, saturated, brown and grey		22-5			
		END OF BOREHOLE (4.57 metres)					-1
5							
6							-2
7							-3
8							-4
9							-5
10							-6
11							-7
12							-8

TETRA TECH EBA	Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 4.57 m
	Drilling Rig Type:	Start Date: 2014 September 19
	Logged By: MG	Completion Date: 2014 September 19
	Reviewed By: CM	Page 1 of 1

Borehole No: 14BH24

Project: DETAILED SITE INVESTIGATION	Project No: ENVIND03511-01.003
Location: 1 PORT DRIVE	Ground Elev: 3.02 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	SAND (FILL) - some gravel, trace silt, fine grained sand, damp, loose, brown					3
		SAND (COAL WASTE FILL) - some gravel, some silt, occasional cobbles, damp, medium dense, black		24-1			
1		- black coal		24-2			2
		SILT (FILL) - sandy, gravelly, dry, dense, light brown - wood piece					1
2		SAND (COAL WASTE FILL) - some silt, trace gravel, moist, black		24-3			
		SILT (FILL) - some sand, some gravel, moist, hard, brown					0
3		SAND - gravelly, trace silt, saturated, loose					
		- wood waste		24-4			-1
4		- wood					
5				24-5			-2
6		END OF BOREHOLE (6.10 metres)					-3
7							-4
8							-5
9							-6
10							-7
11							-8
12							

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 6.1 m
Drilling Rig Type:	Start Date: 2014 September 18
Logged By: MG	Completion Date: 2014 September 18
Reviewed By: CM	Page 1 of 1

Borehole No: **14BH28**

Project: DSI - 1 PORT DRIVE	Project No: ENVIND03511-01.004
Location: 1 PORT DRIVE	Ground Elev: 4.41 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	ASPHALT - (70 mm thick)					4
		SILT (COAL WASTE FILL) - sandy, damp, soft, black		28-1			
		SAND (COAL WASTE FILL) - trace of gravel, trace of silt, medium to coarse grained sand, damp, loose, brown and black		28-2			3
1							
		- coarse grained sand					2
2				28-3			
		COAL (FILL) - sandy, some small gravel, damp, loose, black					1
3							
		SAND AND GRAVEL (FILL) - some coal, trace of silt, moist, medium dense, black		28-4			0
4		GRAVEL (FILL) - sandy, saturated, sticky, loose, dark brown		28-5			
		ASH (FILL) - silt-like, damp, light grey					-1
5		GRAVEL - some sand, saturated, brown		28-6			
		END OF BOREHOLE (5.49 metres) Note: Refusal on suspected bedrock. All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)					-2
6							
7							-3
8							-4
9							-5
10							-6
11							-7
12							

TETRA TECH EBA

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 5.49 m
Drilling Rig Type:	Start Date: 2014 November 13
Logged By: MG	Completion Date: 2014 November 13
Reviewed By: SS	Page 1 of 1

Borehole No: **14BH30**

Project: DSI - 1 PORT DRIVE	Project No: ENVIND03511-01.004
Location: 1 PORT DRIVE	Ground Elev: 3.36 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	ASPHALT - (70 mm thick) SILT (FILL) - some sand, dry, soft, light brown, (80 mm thick) SAND (COAL WASTE FILL) - some coal, trace of fine gravel, medium to coarse grained sand, damp, loose, brown and black					3
1		SILT (COAL WASTE FILL) - sandy, trace of gravel, fine to coarse grained sand, damp, soft, brown and black		30-1			2
2		SAND (COAL WASTE FILL) - some silt, some gravel, some coal, fine to coarse grained sand, moist, medium dense, black		30-2			1
		SAND - trace of silt, homogenous, fine grained, moist, light brown		30-3			
3		GRAVEL - some silt, some sand, fine gravel, saturated, medium dense, grey - saturated - trace of silt, very wet, loose					0
4				30-4			-1
		END OF BOREHOLE (4.57 metres) Note: All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)					
5							-2
6							-3
7							-4
8							-5
9							-6
10							-7
11							-8
12							

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 4.57 m
Drilling Rig Type:	Start Date: 2014 November 13
Logged By: MG	Completion Date: 2014 November 13
Reviewed By: SS	Page 1 of 1

TETRA TECH EBA

Borehole No: 14BH31

Project: DSI - 1 PORT DRIVE	Project No: ENVIND03511-01.004
Location: 1 PORT DRIVE	Ground Elev: 4.02 masl
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Elevation (m)
0	Solid stem auger	SAND (COAL WASTE FILL) - some fine gravel, some coal, trace of silt, fine to coarse grained san,d damp, loose, black, no visible staining, no discernible odour		31-1			4
1				31-2			3
2				31-3			2
3		SAND - trace of silt, homogenous, fine grained, saturated, medium dense, trace of broken seashells, no visible staining, no discernible odour		31-4			1
4				31-5			0
5		END OF BOREHOLE (4.57 metres) Note: All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)					-1
6							-2
7							-3
8							-4
9							-5
10							-6
11							-7
12							

Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 4.57 m
Drilling Rig Type:	Start Date: 2014 November 13
Logged By: MG	Completion Date: 2014 November 13
Reviewed By: SS	Page 1 of 1

Borehole No: **15BH37**

Project: DSI - 1 PORT DRIVE	Project No: ENVIND03511-01.008
Location: 1 PORT DRIVE	
NANAIMO, BRITISH COLUMBIA	

Depth (m)	Method	Soil Description	Sample Type	Sample Number	Vapour readings (ppmv) 100 200 300 400	Notes and Comments	Backfill	Depth (ft)
0								0
	Solid stem auger	ASPHALT COAL WASTE - sandy, gravelly, silty, some angular cobbles, medium to coarse grained sand, subangular gravel, moist, black staining, coal inclusions - some silty grey sand, some reddish brick inclusions						
1								2
								4
2		- boulders - some clay, dense for 300 mm						6
								8
3								10
								12
4		- trace of sand and silt, moist, sheen on soil, noticeable sweet hydrocarbon odour		37-1				14
5		SAND - silty, moist, loose, grey		37-2				16
								18
6		END OF BOREHOLE (6.00 metres) Note: Backfilled at completion. All samples were collected from solid stem auger flight (no split spoon samples or SPT blow counts)						20
								22
7								24
8								26
								28
9								30
								32
10								34
11								36
								38
12								39

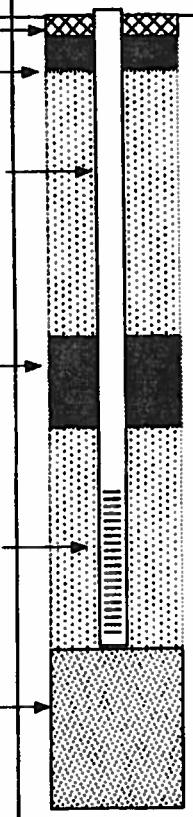
Contractor: DRILLWELL ENTERPRISES LTD.	Completion Depth: 6 m
Drilling Rig Type:	Start Date: 2015 March 26
Logged By: DT	Completion Date: 2015 March 26
Reviewed By: SS	Page 1 of 1

BOREHOLE No. BH98-01 (MW98-01)

TYPE OF RIG: Truck Mounted Auger Rig
DRILLING CONTRACTOR: UNIWDE DRILLING LTD.
DATE DRILLED: April 2, 1998
STEEL CASING STICK UP:
LOCATION: 21 Esplanade Street, Nanaimo, B.C.
Note: Level survey established assumed benchmark of 10 m-asl @MW98-04

SURFACE CONDITION: Asphalt
ELEV. TOP OF PVC: 6.61 m-asl
DEPTH TO WATER : 4.89 m-btoc
ELEVATION OF WATER: 1.72 m-asl
GROUND ELEVATION : N/A m-asl
Date of Water Level Taken: April 3, 1998

Depth (m)	Elev (m-asl)	LITHOLOGIC DESCRIPTION	WELL CONSTRUCTION MATERIALS	Interval	Type	PID (ppm)	Sample Number
0.0	0.0	Asphalt	Piezometer covered by flushmount completion				
		Black SAND & GRAVEL, some Coal Clinker and Pebbles. Dry to Damp No Odours.	Cement Collar; Bentonite Plug; Silica Sand (0.4 - 2.2m)		AS		BH98-1-1
1.0					AS		BH98-1-2
2.0					AS		BH98-1-3
		2.5m					
		Brown Silty SAND & GRAVEL, some Pebbles, trace Clay. Moist to Wet No Odours. 3.0m			AS		BH98-1-4
3.0							
		Broken SHALE & GRAVEL, Damp to Moist. No Odours. 3.75m	Bentonite Plug (3.0 - 4.0 m)				
4.0		Grey coarse gr. SAND & GRAVEL, some Pebbles. 3.9m			AS		BH98-1-5
		Black Clayey SAND & GRAVEL, some Pebbles. 4.1m			AS		BH98-1-6
		Grey Sandy SILT, some Pebbles, trace Clay. Wet. No Odours.	Static Water Level; Screen (4.5 - 6.0 m bgs)		AS		BH98-1-7
5.0							
6.0			Native Backfill (6.0 - 7.5m)				
7.0		7.5m					
		END OF HOLE 7.5m					
8.0							
9.0							
10.0		"AS" Indicates Sample Collected from Auger flyte.					



BC HYDRO

GeoViro Engineering Ltd.
Consulting Engineers and Environmental Scientists

Stage 2 Preliminary Site Investigation
Canadian Pacific Railway, Nanaimo, B.C.
Project No. GV 318

MONITORING WELL LOG

BY: AE
DATE: May 1998
APPROVED:
FIG: BH98-01

BOREHOLE No. BH98-02 (MW98-02)

TYPE OF RIG:	Truck Mounted Auger Rig		SURFACE CONDITION:		Asphalt
DRILLING CONTRACTOR:	UNIWDE DRILLING LTD.		ELEV. TOP OF PVC:	5.63	m-asl
DATE DRILLED:	April 2, 1998		DEPTH TO WATER :	3.91	m-btoc
STEEL CASING STICK UP:			ELEVATION OF WATER:	1.72	m-asl
LOCATION: 21 Esplanade Street, Nanaimo, B.C.			GROUND ELEVATION :	N/A	m-asl
Note: Level survey established assumed benchmark of 10 m-asl @MW98-04			Date of Water Level Taken:	April 3, 1998	

Depth (m)	Elev.(m-asl)	LITHOLOGIC DESCRIPTION	WELL CONSTRUCTION MATERIALS	Well Diagram	Interval	Type	PID (ppm)	Sample Number
0.0	0.0	*Asphalt*	Piezometer covered by flushmount completion					
		Black fine gr. SAND & GRAVEL, some Pebbles, brick fragments, Coal Clinker. Damp to Moist. No Odours.	Cement Collar Bentonite Plug (0.3 - 0.6m) Silica Sand (0.6 - 2.7m)			AS		BH98-2-1
1.0						AS		BH98-2-2
2.0						AS		BH98-2-3
3.0		3.0m	Bentonite Plug (2.7 - 3.0 m)					
		Brown fine to med gr. SAND, trace Pebbles. Moist. 3.5m	Silica Sand (3.0 - 5.2m)					
4.0		Grey fine gr. SAND & GRAVEL some Coal Clinker	Static Water Level			AS		BH98-2-4
5.0		Auger Refusal @ 5.2 m (Possible Bedrock Surface) 5.2m	Screen (3.7 - 5.2 m)					
		END OF HOLE @ 5.2m						
6.0								
7.0								
8.0								
9.0								
10.0		"AS" Indicates Sample Collected from Auger flyte.						

BC HYDRO

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Consulting Engineers and Environmental Scientists

Stage 2 Preliminary Site Investigation
Canadian Pacific Railway, Nanaimo, B.C.
Project No. GV 318

MONITORING WELL LOG

BY: AE
APPROVED:
DATE: May 1998
FIG: BH98-02

BOREHOLE No. BH98-03 (MW98-03)

TYPE OF RIG:	Truck Mounted Auger Rig	SURFACE CONDITION:		Asphalt
DRILLING CONTRACTOR:	UNIWDE DRILLING LTD.	ELEV. TOP OF PVC:	5.59	m-asl
DATE DRILLED:	April 2, 1998	DEPTH TO WATER :	3.87	m-btoc
STEEL CASING STICK UP:		ELEVATION OF WATER:	1.72	m-asl
LOCATION: 21 Esplanade Street, Nanaimo, B.C.		GROUND ELEVATION :	N/A	m-asl
Note Level survey established assumed benchmark of 10 m-asl @MW98-04		Date of Water Level Taken:	April 3, 1998	

Depth (m)	Elev (m-asl)	LITHOLOGIC DESCRIPTION	WELL CONSTRUCTION MATERIALS	Interval	Type	PID (ppm)	Sample Number
0.0	0.0	*Asphalt*	Piezometer covered by flushmount completion				
		Black fine to me gr. SAND, some Pebbles, Coal Clinker. Dry No Odour	Cement Collar; Bentonite Plug (0.3 - 0.6m); Water level		AS		BH98-03-1
1.0							
		1.5m					
2.0		Black stoney fine to med gr. SAND, some Pebbles, Coal Clinker. Dry. No Odours. Water Seepage @ 3.8 m	Silica Sand (0.6 - 2.1m)		AS		BH98-03-2
3.0			Bentonite Plug (2.1 - 3.0m); Silica Sand (3.0 - 5.2m); Static Water Level				
4.0					AS		BH98-03-3
5.0							
		5.2 m	Screen (3.7 - 5.2m)				
		Brown fine to med gr. SAND & GRAVEL, Trace Pebbles. No Odours.			AS		BH98-03-4
6.0		6.0m	Native Backfill (5.2 - 6.0m)				
		END OF HOLE 6.0 m					
7.0							
8.0							
9.0							
10.0		"AS" Indicates Sample Collected from Auger flyte.					

Well Diagram

BC HYDRO

GeoViro Engineering Ltd.
Consulting Engineers and Environmental Scientists

Stage 2 Preliminary Site Investigation
Canadian Pacific Railway, Nanaimo, B.C.
Project No. GV 318

MONITORING WELL LOG

BY: AE

DATE: May 1998

APPROVED:

FIG: BH98-03

BOREHOLE No. BH98-04 (MW98-04)

TYPE OF RIG:	Truck Mounted Auger Rig	SURFACE CONDITION:		Gravel	
DRILLING CONTRACTOR:	UNIWDE DRILLING LTD.	ELEV. TOP OF PVC:	10.00	m-asl	
DATE DRILLED:	April 2, 1998	DEPTH TO WATER :	8.00	m-btoc	
STEEL CASING STICK UP:		ELEVATION OF WATER:	2.00	m-asl	
LOCATION: 21 Esplanade Street, Nanaimo, B.C.		GROUND ELEVATION :	N/A	m-asl	
Note: Level survey established assumed benchmark of 10 m-asl @MW98-04		Date of Water Level Taken:	April 3, 1998		

Depth (m)	Elev (m-asl)	LITHOLOGIC DESCRIPTION	WELL CONSTRUCTION MATERIALS	Interval	Type	PID (ppm)	Sample Number
0.0	0.0	*Gravel*	Piezometer covered by flushmount completion				
		Black fine to med gr. SAND, some Coal Clinker, Brick Mortar fragments, Pebbles. Moderately dense. Dry. No odours. 1.5m	Cement Collar; Bentonite Plug (0.3 - 1.0m)		AS		BH98-04-1
2.0		Black coarse gr. COAL CLINKER, some Sand, Pebbles, Cobbles Damp. No Odours. 3.0m			AS		BH98-04-2
3.0		Brown fine to med gr. SAND, some coarse gr. Gravel trace Pebbles and Silt. Damp. No Odours. 5.0m	Silica Sand (1.0 - 6.0m)		AS		BH98-04-3
4.0		Brown fine to coarse gr. SAND & GRAVEL, some Pebbles. Moist to Wet. No Odours. 7.3m			AS		BH98-04-4
6.0			Bentonite Plug (6.0 - 7.1m)				
7.0		Brown fine to med gr. SAND. Moist to Wet. 7.5m	Silica Sand (7.1 - 9.0m)		AS		BH98-04-5
		Brown med to coarse gr. SAND, some Pebbles. Wet.	Static Water Level; Screen (7.6 - 9.1m)				
8.0							
9.0		9.1m					
		END OF HOLE 9.1 m					
10.0		"AS" Indicates Sample Collected from Auger flyte.					

Well Diagram

BC HYDRO

GeoViro Engineering Ltd.
Consulting Engineers and Environmental Scientists

Stage 2 Preliminary Site Investigation
Canadian Pacific Railway, Nanaimo, B.C.
Project No. GV 318

MONITORING WELL LOG

BY: AE

DATE: May 1998

APPROVED:

FIG: BH98-04

BOREHOLE No. BH98-05 (MW98-05)

TYPE OF RIG:	Truck Mounted Auger Rig		SURFACE CONDITION:		Gravel
DRILLING CONTRACTOR:	UNIWDE DRILLING LTD.		ELEV. TOP OF PVC:	8.22	m-asl
DATE DRILLED:	April 2, 1998		DEPTH TO WATER :	6.50	m-btoc
STEEL CASING STICK UP:			ELEVATION OF WATER:	1.72	m-asl
LOCATION: 21 Esplanade Street, Nanaimo, B.C.			GROUND ELEVATION :	N/A	m-asl
Note: Level survey established assumed benchmark of 10 m-asl @MW98-04			Date of Water Level Taken:	April 3, 1998	

Depth (m)	Elev (m-asl)	LITHOLOGIC DESCRIPTION	WELL CONSTRUCTION MATERIALS	Well Diagram	Interval	Type	PID (ppm)	Sample Number
0.0	0.0	*Gravel*	Piezometer covered by flushmount completion					
		Black Silty fine to med gr. SAND, some Coal Clinker, trace Brick fragments. Damp . No odours.	Cement Collar Bentonite Plug (0.3 - 1.0m)			AS		BH98-05-1
1.0								
2.0						AS		BH98-05-2
3.0			Silica Sand (0.6 - 4.5m)					
4.0						AS		BH98-05-3
5.0			Bentonite Plug (4.5 - 5.5m)					
6.0		Wet @ 6.0 m	Silica Sand (5.5 - 7.6m)			AS		BH98-05-4
		6.5m	Static Water Level					
7.0		Brown Stoney SILT, some Sand. Wet. No odours.	Screen (6.1 - 7.6m)					
		7.6m						
8.0		END OF HOLE 7.6 m						
9.0								
10.0		"AS" Indicates Sample Collected from Auger flyte.						

BC HYDRO

GeoViro Engineering Ltd.
Consulting Engineers and Environmental Scientists

Stage 2 Preliminary Site Investigation
Canadian Pacific Railway, Nanaimo, B.C.
Project No. GV 318

MONITORING WELL LOG

BY: AE
APPROVED:
DATE: May 1998
FIG: BH98-05

JACQUES WHITFORD
ENVIRONMENT LIMITED

BOREHOLE RECORD

BH2

CLIENT Nanaimo Interlink

PROJECT No. 32142-5705

LOCATION 21 Esplanade Street, Nanaimo, BC

DATUM

DATES: BORING 96-04-18

WATER LEVEL

TPC ELEV.

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	VAPOUR CONCENTRATIONS ● %LEL ▲ ppm	SAMPLES TYPE	SAMPLES N-VALUE	WELL CONSTRUCTION
0		**Ground Surface**				● 20 40 60 80 ▲ 100 200 300 400			
		ASPHALT							
		Black/brown, loose, SAND, medium grained, some coal, dry - no hydrocarbon odour			2				
1							SS17	8	
		- trace yellow granules @ 1.5 m			4				
2					6		SS18	2	
		- black, compact, trace coarse gravel, little coal, moist - no hydrocarbon odour			8		SS19	13	
3					10		SS20	18	
		- wet @ 3.8 m - brown @ 3.9 m			12				
4					14		SS21*	34	
		- light brown, compact to dense, wet, @ 4.6 m - no hydrocarbon odour			16		SS22	29	
5		- dense, some shells, saturated @ 5.3 m - no hydrocarbon odour			18		SS23	50	
6					20		SS24	50	
		END of BOREHOLE (6.5 m) Water @ 4.0 m upon completion * Soil sample submitted for analysis			22				
7					24				
8					26				
9					28				
					30				
10					32				

DRAFT

BOREHOLE No. BH01-23/MW01-21

TYPE OF RIG :	Track-mounted SSA	SURFACE CONDITION :	Gravel
DRILLING CONTRACTOR :	Drillwell Enterprises	ELEV. TOP OF PVC :	7.52 m-asl
DATE DRILLED :	August 2, 2001	DEPTH TO WATER :	4.08 m-btor
CASING TYPE :	51 mm PVC	ELEVATION OF WATER :	3.44 m-asl
LOCATION :	Nanaimo, B.C.	GROUND ELEVATION :	7.59 m-asl
SUPERVISED BY :	Chuck Jochems	DATE OF WATER LEVEL :	August 15, 2001

Depth (m)	Elev.(m-asl)	LITHOLOGIC DESCRIPTION	WELL CONSTRUCTION MATERIALS	Interval	Sample Type	Recovery	Blow Counts	Gastech (ppm)	Sample Number
	7.59	Asphalt (0.06 m)	Well completed with flushmount cover					bkgd 0	
0.0			Concrete Collar						
		FILL, clay brick and coal, some wood debris. Dry No Hydrocarbon (HC) odour.	Drill Cuttings (0.3 - 1.0 m)		AS			150	Headspace
	6.69	0.9 m							
1.0			Bentonite Plug (1.0 - 1.5 m)						
			Cement Grout (1.5 - 2.1 m)		AS			165	Headspace
2.0		Coal FILL with some wood and cinders. Dry to damp No HC odour.	Bentonite Plug (2.1 - 2.7 m)		AS			195	Headspace
3.0					AS			175	Headspace
	3.59	4.0 m	Sand (2.7 - 6.1 m)		AS			450	Headspace
4.0		Black SILT with marine shells, pebbles and gravel. No HC odour. Wet below 4.2 m.							BH23(4.3m)
	2.89	4.7 m	Screen (3.0 - 6.1 m)		AS			350	Headspace
5.0		Dark grey silty medium SAND. Wet. No HC odour.			AS			250	Headspace
6.0	1.49	6.1 m			AS			140	Headspace
		END OF HOLE @ 6.1 m							
7.0									
8.0									
9.0									

CLIENT:

Canadian Pacific Railway

GeoViro Engineering Ltd.
Consulting Engineers and Environmental Scientists

PROJECT: Hydrocarbon Plume Delineation
CPR Wellcox Yard
Esplanade St. and Crace St., Nanaimo, B.C.
GeoViro No. GV520.02

BOREHOLE / MONITORING WELL LOG

BY: CJ

DATE: AUGUST 2001

APPROVED:

LOG: BH01-23/MW01-21

SNC·LAVALIN Environment

Client : Canadian Pacific Railway

Location : Wellcox Yard, Nanaimo, British Columbia

Borehole No. : 09-6

(Page 1 of 1)

Drilling Contractor: McRae's Environmental/Beck Drilling and Enviro..
Drilling Method : Hydrovac/Solid Stem Auger
Borehole Dia. (m) : 0.20
Pipe/Slotted Pipe Dia. (m): 0.05, 0.05

Date Monitored : 2009 04 14
Ground Surf Elev. (m) : 7.37
Top of Casing Elev. (m) : 7.291

Project Number : 133869
Borehole Logged By : DF/MM
Date Drilled : 2009 04 06
Log Typed By : MAL

Drilling Legend: Sample Interval; Day-Lighting; Auger Flight

Water/NAPL Levels: Water Level 1; Water Level 2; NAPL; NAPL

Reading within indicated scale; Reading outside indicated scale

Solid PVC; Slotted PVC

Well Name: MW09-6

Depth In Metres	Soil Description	Stratigraphy Plot	Sample Interval/ Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm) 1 10 2 10 3 10 4 10
0	ASPHALT.						
	SAND and GRAVEL (FILL), medium to coarse grained sand, subangular gravel, some coal, moist.			6-1			75
1				6-2			75
	SAND, fine grained, light brown, loose, damp.			6-3			25
2				6-4			50
	SAND, some silt, trace medium to coarse gravel, subangular, dark brown, compact, damp.			6-5			25
	SAND, fine grained, light brown, loose, damp.			6-6			15
3				6-7			10
4				6-8			
	SAND, fine grained, some silt, trace gravel, medium to coarse, subrounded, dark brown, compact, damp.			6-9			30
5				6-10*			
	SAND, orange-brown, loose, moist.			6-11			25
6							
	Below 6.7 m - trace silt, trace gravel, fine, compact, wet.			6-12			120
7				6-13			20
	End of borehole at 7.6 m.						
8							
9							
10							

Road Box
CONCRETE
BENTONITE
SAND

Notes:
Bolded sample denotes sample analyzed.
*Sample 6-10 is a blind field duplicate of 6-9.
Borehole day-lighted to a depth of 2.3 m on 2009 04 06.
Well installed with a hollow stem auger.

Print Date: 2009 06 23, Date Approved: 2009 06 22

SNC·LAVALIN Environment

Client : Canadian Pacific Railway

Location : Wellcox Yard, Nanaimo, British Columbia

Borehole No. : 09-18

(Page 1 of 1)

Drilling Contractor: McRae's Environmental/Beck Drilling and Enviro.
Drilling Method : Hydrovac/Solid Stem Auger
Borehole Dia. (m) : 0.15

Ground Surf Elev. (m) : 5.52

Project Number : 133669
Borehole Logged By : DF/MM
Date Drilled : 2009 04 06
Log Typed By : MAL

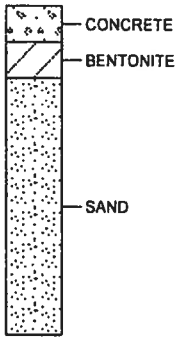
Drilling Legend: Sample Interval; Day-Lighting; Auger Flight

Water/NAPL Levels: Water Level 1; Water Level 2; NAPL; NAPL

Reading within indicated scale
Reading outside indicated scale

Soil Vapour (ppm): 1 10, 2 10, 3 10, 4 10

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval/ Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm)
0	ASPHALT.						
	SAND and GRAVEL (FILL), fine to medium grained sand, some coal, trace silt, black, loose, damp.			18-1			75
1				18-2			100
	SAND (FILL), fine grained, silt, some coal, black/brown, loose, damp.			18-3			75
	Below 1.7 m - trace silt, black.			18-4			50
2	COAL, trace gravel, subangular, loose, damp.			18-5			10
	Below 2.7 m - bedrock.			18-6			
3	End of borehole at 2.7 m.						
4							
5							
6							
7							
8							
9							
10							



Notes:
Bolded sample denotes sample analyzed.
Borehole day-lighted to a depth of 1.8 m on 2009 04 06.

Print Date: 2009 06 23, Date Approved: 2009 06 23

SNC·LAVALIN Environment

Client : **Canadian Pacific Railway**

Location : **Wellcox Yard, Nanaimo, British Columbia**

Borehole No. : 09-19

(Page 1 of 1)

Drilling Contractor: McRae's Environmental/Beck Drilling and Enviro..
Drilling Method : Hydrovac/Solid Stem Auger
Borehole Dia. (m) : 0.20
Pipe/Slotted Pipe Dia. (m): 0.05, 0.05

Date Monitored : 2009 04 14
Ground Surf Elev. (m) : 2.764
Top of Casing Elev. (m) : 2.677

Project Number : 133669
Borehole Logged By : DF/MM
Date Drilled : 2009 04 06
Log Typed By : MAL

Drilling Legend: Sample Interval; Day-Lighting; Auger Flight

Water/NAPL Levels: Water Level 1; Water Level 2; NAPL; NAPL

Reading within indicated scale; Reading outside indicated scale

Soil Vapour (ppm) 1 10 2 10 3 10 4 10

Solid PVC; Slotted PVC

Well Name: MW09-19

Depth in Metres	Soil Description	Sample Number	Soil Vapour (ppm)
0	ASPHALT.		
	SAND and GRAVEL (FILL), medium to coarse grained sand, subrounded gravel, cobbles, brown, moist.	19-1	15
	COAL, moist.	19-2	125
1		19-3	150
		19-4	125
2	SAND and COAL (FILL), (7.5 mm - 19.0 mm), some gravel, fine, subangular, trace silt, brown/black, loose, moist.		
	Below 2.4 m - wet.	**19-5** **19-6***	50
3		19-7	30
		19-8	30
4	SAND (NATIVE), trace silt, dark brown, loose, wet.	19-9	20
5		19-10	10
	Below 5.9 m - fine grained sand, trace to some silt, grey/brown, damp to moist, trace shell fragments, sulphur-like odour.	19-11	
6		19-12	
7		19-13	
	Below 7.5 m - medium grained sand, no silt, grey, wet.		
	End of borehole at 7.6 m.		
8			
9			
10			

Road Box
CONCRETE
BENTONITE
SAND
SLOUGH

Notes:
Bolded sample denotes sample analyzed.
*Sample 19-6 is a blind field duplicate of 19-5.
Borehole day-lighted to a depth of 1.8 m on 2009 04 06.
Well installed with a hollow stem auger.

Print Date: 2009 06 23, Date Approved: 2009 06 22

SNC·LAVALIN Environment

Client : **Canadian Pacific Railway**

Location : **Wellcox Yard, Nanaimo, British Columbia**

Borehole No. : 09-2

(Page 1 of 1)

Drilling Contractor : McRae's Environmental/Beck Drilling and Enviro..
Drilling Method : Hydrovac/Solid Stem Auger
Ground Surf Elev. (m) : 3.06

Project Number : 133689
Borehole Logged By : DF/MM
Date Drilled : 2009 04 06
Log Typed By : MAL

Drilling Legend: Sample Interval; Day-Lighting; Auger Flight

Water/NAPL Levels: Water Level 1; Water Level 2; NAPL; NAPL

Soil Description

Depth in Metres	Soil Description	Sample Number	Soil Vapour (ppm)
0	ASPHALT.		
	SAND and GRAVEL (FILL), medium to coarse grained sand, subrounded gravel, cobbles, brown, moist.	2-1	75
	COAL, loose, moist.	2-2	75
1		2-3	75
		2-4	50
2	COAL, some sand, medium to coarse grained, trace silt, brown/black, moist.	2-5	40
	Below 2.7 m - wet.	2-6	30
3		2-7*	
		2-8	20
4		2-9	15
	End of borehole at 4.6 m.		
5			
6			
7			
8			
9			
10			

CONCRETE
BENTONITE
SAND

Notes:
Bolded sample denotes sample analyzed.
*Sample 2-7 is a blind field duplicate of 2-6.
Borehole day-lighted to a depth of 1.8 m on 2009 04 06.

Print Date: 2009 06 23, Date Approved: 2009 06 22

SNC•LAVALIN Environment

Client : **Canadian Pacific Railway**

Location : **Wellcox Yard, Nanaimo, British Columbia**

Borehole No. : 09-3

(Page 1 of 1)

Drilling Contractor: McRae's Environmental/Beck Drilling and Enviro..
Drilling Method : Hydrovac/Solid Stem Auger
Borehole Dia. (m) : 0.20
Pipe/Slotted Pipe Dia. (m): 0.05, 0.05

Date Monitored : 2009 04 14
Ground Surf Elev. (m) : 4.331
Top of Casing Elev. (m) : 4.212

Project Number : 133669
Borehole Logged By : DF/MM
Date Drilled : 2009 04 06
Log Typed By : MAL

Drilling Legend: Sample Interval; Day-Lighting; Auger Flight

Water/NAPL Levels: Water Level 1; Water Level 2; NAPL; NAPL

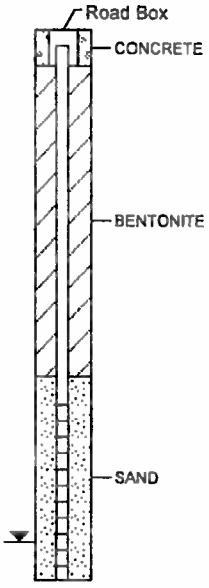
Reading within indicated scale; Reading outside indicated scale

Soil Vapour (ppm) 1 10 2 10 3 10 4 10

Solid PVC; Slotted PVC

Well Name: MW09-3

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval/ Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm)
0	ASPHALT.						
	SAND and GRAVEL (FILL), medium to coarse grained sand, subrounded gravel, cobbles, some coal, trace clay, loose, damp.			3-1			75
1				3-2			50
	COAL, trace brick, trace wood, loose, moist.			3-3			75
				3-4			50
2	COAL and GRAVEL (FILL), coarse gravel, subangular, some sand, trace silt, dark brown/black, compact, damp to moist.			3-5			15
3	SAND and GRAVEL (FILL), fine grained sand, coarse gravel, subangular, trace silt, grey/brown, compact, damp to moist.			3-6			15
	SAND (FILL), fine grained, some silt, trace gravel, fine to coarse, subangular, trace coal waste, compact, damp to moist.						
4	Below 3.8 m - moist to wet.			3-7 3-8*			15
	Below 4.3 m - wet.			3-9			10
	Below 4.6 m - bedrock.						
5	End of borehole at 4.6 m.						
6							
7							
8							
9							
10							



Notes:
Bolded sample denotes sample analyzed.
*Sample 3-8 is a blind field duplicate of 3-7.
Borehole day-lighted to a depth of 1.8 m on 2009 04 06.
Well installed with a hollow stem auger.

Print Date: 2009 06 23, Date Approved 2009 06 23